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# Investigation of use of the Tire Impact Machine as Standard Device for Rating Impact Sound Transmission of Floors

**Étude sur l'utilisation du générateur d'impact à roue comme dispositif standard pour déterminer la transmission des bruits de choc par les planchers**


**Résumé de l'étude**

Cette recherche a pour but de mettre au point un essai visant l'évaluation de la transmission des bruits de choc de basse fréquence par des planchers légers qu'on trouve habituellement dans les bâtiments canadiens. L'essai proposé consiste à modifier une norme japonaise ayant recours à une roue de petite voiture (pneu et jante) en guise de générateur d'impact.

La transmission des bruits de choc est mesurée sur 75 planchers différents. Quatre générateurs d'impact sont employés : un assemblage pneu-jante, un marcheur humain, la machine à choc standard de l'ASTM et de l'ISO ainsi qu'un générateur d'impact spécial mis au point pour les besoins du CNR. La perte de transmission des bruits aériens est aussi mesurée puisqu'elle est facile à réaliser.

Seulement deux générateurs d'impact parmi ceux mis à l'essai pourraient être sérieusement envisagés pour une nouvelle méthode d'essai : la machine à choc de l'ASTM et de l'ISO, et le dispositif pneu-jante. L'analyse des données recueillies pour les planchers à l'essai révèle que le dispositif à roue offre la meilleure corrélation avec le marcheur, ce qui n'est peut-être pas le cas pour tous les types de planchers, car la dimension de ces derniers peut modifier les résultats.

Les données obtenues avec la machine à choc de l'ASTM et de l'ISO présentent aussi une bonne corrélation avec celles produites par le marcheur lorsque l'on procède à des comparaisons par bandes de tiers d'octave. L'indice à un chiffre présentement utilisé, c'est-à-dire l'indice d'isolement aux bruits d'impact (IIC), ne permet pas d'obtenir de bonnes corrélations avec le marcheur.

Les autres indices à un chiffre utilisés pour les données recueillies avec la machine à choc donnent des corrélations avec les résultats du marcheur presque aussi bonnes qu'avec les indices obtenus avec le générateur à roue. L'une des meilleures méthodes utilisées est l'augmentation des niveaux mesurés dans les trois ou quatre bandes les plus graves. Il s'agit alors de calculer la puissance acoustique totale dans la gamme de fréquences comprises entre 50 et 500 Hz.

Le dispositif à roue est peu coûteux, mais peu utilisé. Il est donc plus pratique d'obtenir une mesure précise de la transmission des bruits de choc en ayant recours à la machine à choc de l'ASTM et de l'ISO par la méthode de l'indice à un chiffre modifié.

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# Investigation of use of the Tire Impact Machine as Standard Device for Rating Impact Sound Transmission of Floors.

## Project Summary

The goal of this research project was to develop a test for evaluating the transmission of low-frequency impact sounds through lightweight floor constructions typical of those used in Canadian construction. The proposed test was to be a modified version of an existing Japanese standard that used a small automobile tire and wheel as the impactor.

Measurements were made of impact sound transmission through 75 different floor structures. Four different impact devices were used: a tire/wheel, a human walker, the standard ASTM/ISO tapping machine, and a special impact device developed for research at NRC. Airborne sound transmission loss was also measured since this could be done for very little extra effort.

Only two of the impact devices used were serious candidates for use in a new test procedure: the ASTM/ISO tapping machine and the tire/wheel device. Analysis of the data showed that for the floors tested, single number ratings for the tire machine correlated very well with those for the walker. This may not be true in all cases; floor size may influence the results.

The ASTM/ISO tapping machine data also correlated well with the walker data when comparisons were made in one-third octave bands. The single number rating currently used, impact insulation class (IIC), did not give good correlation with walker results.

Alternative single number ratings used with the tapping machine correlated with the corresponding walker ratings almost as well as did the tire ratings. One of the best procedures used was to increase the measured levels in the lowest 3 or 4 bands, then calculate the total sound power in the frequency range 50 to 500 Hz.

The tire machine is expensive and is not in common use. So, the more practical way to accurately rate impact sound transmission through floors is to use the existing ASTM/ISO tapping machine with the frequency range extended down to 50 Hz and a modified single number rating procedure.

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# Investigation of use of the Bang Machine as Standard Device for Rating Impact Sound Transmission of Floors.

## Introduction and Summary of Project

The noise of footsteps is a common source of annoyance in multi-family dwellings. There is a standard test used to measure impact sound transmission through floors, but research has shown that its ratings do not reliably rank floors as would human subjects listening to walkers. In other words, some floors may be found acceptable according to these tests yet apartment occupants find them unacceptable because of low-frequency thumping noises. This is especially true for wood-joist and similar lightweight constructions with carpeted floors. Often with such floors the carpet ensures a good rating in the standard test, but does little to attenuate low-frequency impact sound. Occupant dissatisfaction can be very high and may lead to litigation and costly repair work, if repair is even possible.

The goal of the research project was to develop a test for evaluating the transmission of low-frequency impact sounds through lightweight floor constructions typical of those used in Canadian construction. The proposal was to use a modified version of an existing Japanese standard that, although in use in that country, needed modification if it were to be used in North America.

Measurements were made of impact sound transmission through several different floor structures. Four different impact devices were used:

- the modified tire and wheel,
- a walker,
- the standard tapping machine, and
- a special impact device developed for research at NRC.

Airborne sound transmission loss was also measured since this could be done for little extra effort.

## Impact Devices Used In Research Project

*Japanese Tire Drop Test*

To deal with the problems of footstep noise on lightweight floors, the Japanese standards organization (JIS) developed an additional test procedure [1] to be used as well as the tapping machine test. A small automobile tire is dropped from a height of 0.9 m onto the floor under test, and sound pressure levels are measured in the room below. Most of the energy generated by this impactor is at low frequencies.

A commercially available tire impactor was purchased (See Fig. 1). The machine and the test method was altered slightly for use in this research study. The reasons for the changes and the details of the revised test procedure are given in Appendix B. Conversations with Japanese research workers since the start of this project have revealed that there is some dissatisfaction with the Japanese test. Alternatives are being investigated in Japan.

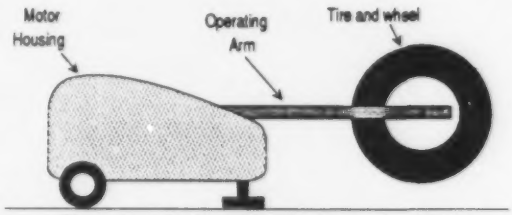


*Figure 1: Sketch of the Rion bang machine.*

*Standard Tapping Machine*

The standard[2] tapping machine has five steel-faced hammers each weighing 0.5 kg. A motor and cam system drives these to strike the floor a total of ten times per second. The drop height is 40 mm. The single number rating obtained is the impact insulation class (IIC)[3]. The use of this tapping machine was first standardized by an ISO test procedure and the machine is referred to in this report as the ISO machine.

*Live Walker*

One criticism made of the standard tapping machine test [2] is that the steel hammers do not properly simulate a human foot. It is common in research into footstep noise to use one or more walkers as a reference. In previous research at NRC, this author has been the walker and continues in that role in these tests. The type of shoe worn has an influence on the noise generated

during walking. The same shoes have been in use for this kind of research for many years at NRC.

*NRC Foot Simulator*

Several years ago, an impactor was developed at NRC. This impactor simulates the force generated by the human foot. Figure 2 shows a sketch of the impactor. This is lowered at a controlled rate by an electronically controlled electro-mechanical system. The impact velocity is 0.3 m/s and the force pulse generated is sketched in Figure 3. The initial narrow force spikes (due to the small 170 g weight) are similar to the force pulses generated by the heel of a shoe.

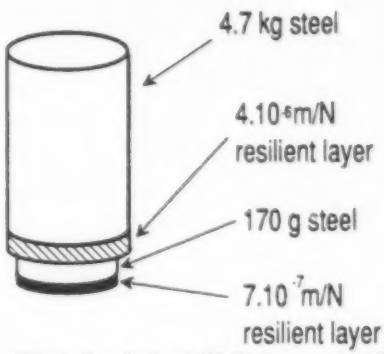


*Figure 2: Sketch of the NRC foot simulator.*

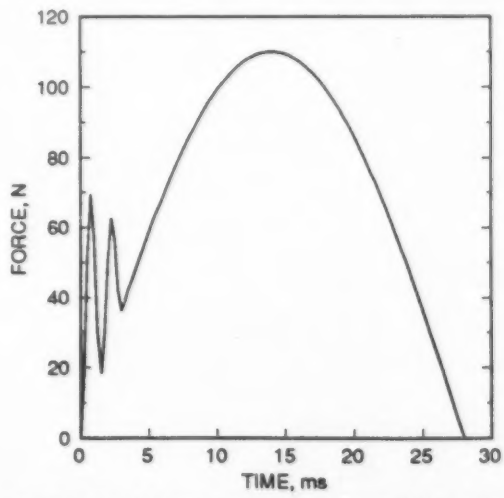


*Figure 3: Typical force pulse generated by the NRC foot impact simulator.*

While the NRC impactor simulates human footfalls well, it does not generate enough sound to make measurement convenient. Even in a laboratory, the

signals can be lost in the background noise. This often happens with human footfalls too. However, data were taken with this machine to provide a link to previous work and to verify the consistency of the human walker.

### Measurement Procedures

Procedures for measurement of airborne sound transmission followed standard practices where possible[5, 8, 2, 3]. Measurements were extended to lower frequencies than required by the standards as detailed in Appendix A.

To measure maximum impulse levels, a single fixed microphone and the procedures described in Appendix A were followed.

### Presentation of results

The intent of the project was to investigate the suitability of the Tire machine as an impact testing device. There was no intention of producing economical floor systems giving good impact sound insulation. Inevitably, however, due to the number of tests made, a good deal of useful information on floor systems was obtained. The results are therefore presented in two parts. The first part discusses the potential for a new test method and the second part discusses the sound insulation of the floor systems tested.

Descriptions of the constructions are in Appendix C. Floor systems are identified there as Joist1, Joist2, Truss1 and so on. A coding system is used in Appendix C to describe the constructions. The same coding system is used in Appendix D where measured data are tabulated.

# I. Potential for New Impact sound test

## Summary

This section deals with the analysis of the data collected during the study. For each impactor, sound pressure levels in one-third octave bands were correlated with those measured for the walker. The established single-number ratings, IIC and A-weighted sound level, were calculated. A modified version of the Japanese single-number rating was defined and called tire insulation class (TIC).

Correlations with walker data were good at frequencies below about 500 Hz for all the impactors. The tire was best at the lowest frequencies but not so good above about 125 Hz. Examination of records for particular floors showed that none of the impactors does a perfect job. The tire, for example, shows no difference in sound level for a concrete floor with or without carpet and underpad; the carpet and underpad significantly reduced the walker levels.

Alternative single-number ratings were used. These included, C-weighted levels, the maximum level measured, the level of the total energy from 50 to 500 Hz, and a rating similar to one proposed by Bodlund[7]. To get better agreement with walker data, alternative low frequency weightings for the tapping machine were used. Correction terms were added to the measured low frequency levels and new ratings calculated; this improved correlation with the walker data.

While the single number ratings from the tire machine usually gave better agreement with those from the walker, the tire machine did not correlate well at frequencies above about 200 Hz. The spectra measured were dominated by the low frequency bands around 50 Hz. This may not always be the case in buildings or other laboratories with floors of different sizes. The tire machine is expensive and not in use outside of Japan.

**For these reasons, the simplest (and probably most acceptable) approach to improved impact testing of floors is to use the ASTM/ISO tapping machine. The frequency range for measurement should be extended to 50 Hz and a single number rating similar to those used here should be introduced.**

# Potential for New Impact sound test

## Introduction

The major goal of this research study was to examine possible new methods for rating the transmission of impact sound through floor systems. This section discusses the major advantages and limitations of the test methods examined.

## Typical Results from impact devices

To give some familiarity with the characteristics of the different impactors and the kinds of spectra measured on different floors, some typical results are now presented. The statistical analysis of the data follows them.

Figure 4 shows the impact sound pressure levels generated on a bare concrete slab. One does not normally find bare concrete slabs in homes, but, these levels would not change much if the floor were finished with tile, parquet or vinyl.

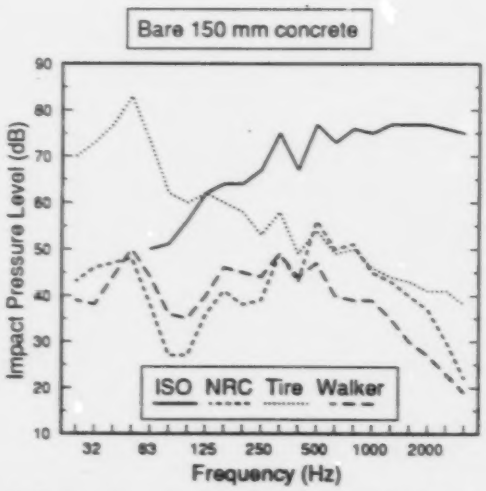


*Figure 4: Impact sound pressure levels for the bare 150 mm concrete slab.*

Some points to note in Fig. 4 are:

- The NRC impactor has a spectrum that is very similar to that from the walker, both in shape and level.

- The spectrum for the tire shows a peak at 50 Hz and it falls steadily as the frequency increases. There is relatively less energy at the middle and high frequencies than there is in the case of the walker.
- The ISO machine spectrum steadily increases with frequency to reach a plateau about 500 Hz. This is quite different from all the other impactors used except that the spectrum is roughly parallel to the walker spectrum up to 500 Hz.

Figure 5 shows results for the same slab with a carpet and underpad placed on top. Now all the curves are roughly parallel but the tapping machine is deficient at the frequencies below about 100 Hz.

These two figures alone give some insight into the problems with the current standardized tapping machine test and the impact insulation class (IIC). In Fig. 4, the IIC of 25 is determined by the levels around 3150 Hz. Even with fairly hard-heeled shoes, the walker does not generate significant sound energy there. When the carpet and underpad is added to the floor, the tapping machine spectrum changes drastically and the IIC increases to 86 — a 61 dB improvement. In comparison, the walker levels around 500 Hz drop by only about 25 dB; at 50 Hz the level drops just 8 dB. Even at this point, it is not encouraging to see that the tire levels are almost exactly the same below 500 Hz; the tire machine underpredicts while the tapping machine overpredicts the effectiveness of carpet and underpad.

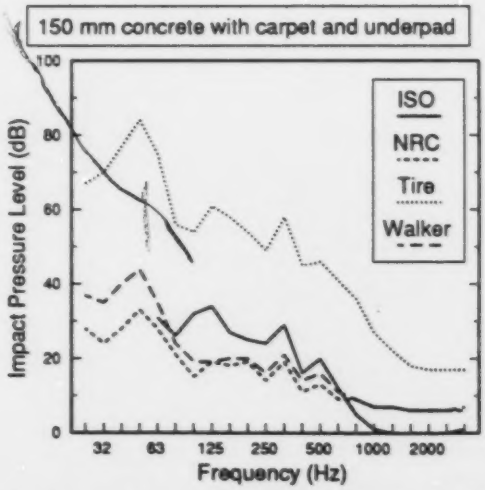


*Figure 5: Impact sound pressure levels for the 150 mm concrete slab covered with a carpet and foam underpad.*

The results in Fig. 6 give more insight. The floating floor assembly, Float2, is 40 mm of concrete resting on 21 mm thick neoprene pads with a Fiberglas AF331 blanket beneath the slab. One can see that the tire machine generates a spectrum that has more low frequency energy relative to the mid-frequencies than the walker spectrum. The tapping machine spectrum,

although quite parallel to the walker over most of the plot, does not have as much low frequency sound relative to the mid-frequencies.

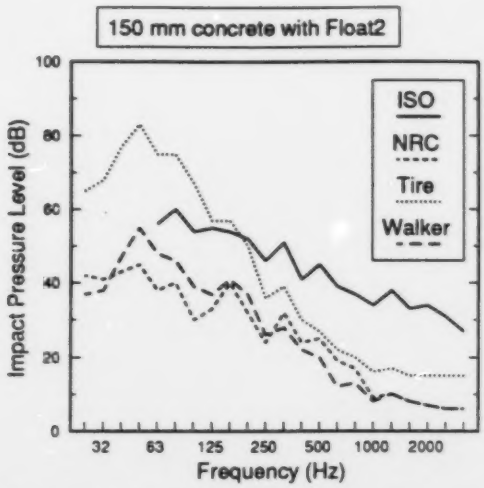


*Figure 6: Impact sound pressure levels for the 150 mm concrete slab with Float2 on top.*

Figures 7 to 9 show results for a wood truss floor system. Points to note for this floor system are:

- The tire machine gives almost the same results whether the floor is carpeted or not.
- With the walker, low frequency levels are about the same in both cases but there is a marked reduction at frequencies around 250 Hz when the carpet is added.
- The tapping machine levels are reduced at all frequencies when the carpet is added, but more so at the higher frequencies.

The tire machine in this case gives a better prediction at low frequencies while the tapping machine again overpredicts the effectiveness of carpet and underpad.

The result in Fig. 9 shows that the floating floor reduces the tire peak at 50 Hz by about 10 dB relative to the bare floor. The ISO machine levels are substantially reduced but the walker low frequency levels only change by about 5 dB.

Note that in all cases shown, the walker spectrum level never increases with increasing frequency as does the tapping machine on the bare concrete. These figures suggest that, in practice, footstep noise is a low frequency problem. The current impact insulation class (IIC) contour which heavily

penalizes bare, hard-surfaced floors at frequencies around 2500 Hz does not appear appropriate. This is discussed further later in the section.

These results are shown only to give some feel for the kind of data collected. It is important to remember that, although the same walker with the same shoes walked in each case, walkers are much more variable than machines. The statistical approach taken in the following sections compensates for this.

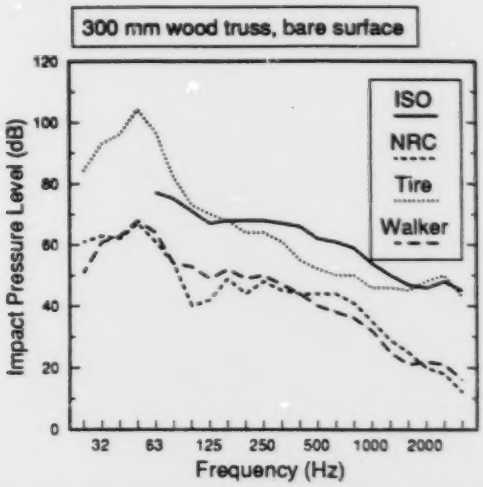


*Figure 7: Impact sound pressure levels for the bare 300 mm wood truss floor.*

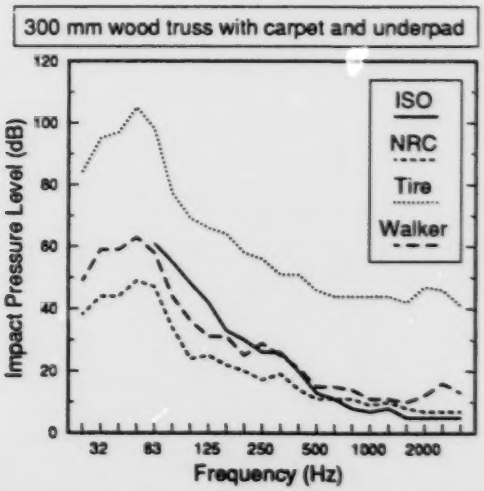


*Figure 8: Impact sound pressure levels for the 300 mm wood truss floor covered with a carpet and foam underpad.*

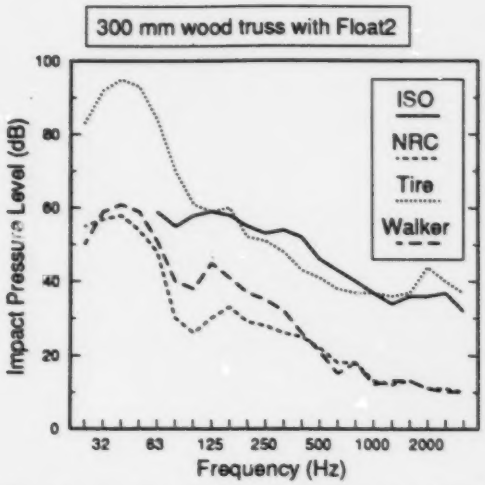


*Figure 9: Impact sound pressure levels for the 300 mm wood truss floor with Float2 on top.*

**Possible test procedures**

Earlier research in this laboratory [6] has shown that using a walker as a standard impactor is not practical. There is too much variation between individuals and no practical hope of standardization of the footstep impact. The foot velocity at impact is critical and this is very difficult to measure. The shoe worn would also have to be standardized as it plays a significant role at frequencies around 250 Hz. Within a laboratory, however, tests using the same walker with the same shoes each time provide a reference to the most common source of impact sound in buildings.

The NRC special impactor generates sound levels that correlate well with those from the walker. This machine, however, is not at all standardized, nor is it easy to use. It would require a considerable amount of work to convert it to a practical device. The levels it generates are about the same as those from a walker. This means that, where the floor system attenuates impact noise effectively, the levels generated in the room below are close to background noise levels and difficult to measure. Measurement in buildings, where background noise levels are higher, would be even more difficult. This device was included in the research program because it provides a link to earlier work. The results can be used to estimate the transmission of tire impacts and ISO hammer impacts through floor systems tested in the past in the NRC laboratory. This will extend the database of constructions with known or estimated low frequency impact sound transmission.

- Thus only two impactors can be seriously considered as candidates for an improved impact test: the ISO machine and the tire machine.

## Correlations Between Levels from Impact Devices

As a first step in the treatment of the data, the correlations between the one-third octave band sound levels for the walker and those generated by the tire machine, the ISO machine and the NRC impactor were calculated. Even if the spectrum shapes for two different impactors are different, the changes in level in each frequency band may be the same when different floors are tested. If this is so, then there should be good correlation on a band-by-band basis. There are theoretical reasons why this should not be so, but, in practice, the variations may be acceptable.

Tables 1 and 2 list the results of the correlations and Figures 10 and 11 plot the square of the correlation coefficient for each frequency. (In preparing the table, only data where the walker sound levels were at least 10 dB above background noise were used. Much of the data collected at high frequencies was contaminated by background noise, so the frequency range is limited to 1250 Hz. In any case, correlations at higher frequencies were very poor.)

The tables and figures were prepared for two cases: one where all floors tested were included and the other where only uncarpeted floors were included. This was done because it is sometimes suggested that excluding tests from carpeted floors gives better correlation with subjective ratings and walker sound levels. The data in this work support this viewpoint.

These tables and figures show the following:

- The NRC impactor correlates well from about 80 to 500 Hz but poorly at lower frequencies.

- The tire results correlate well from 25 Hz to about 100 but not so well above that frequency. The poor correlation around 500 Hz arises because the walker wore shoes; these cause a characteristic bump in the impact spectrum around 500 Hz. It was not possible to fit the same shoes on the tire.

- The ISO machine correlates quite well from 50 to about 250 Hz. This last observation is perhaps surprising; it suggests that, despite the criticism directed at it, the ISO machine can be used to predict walker levels fairly accurately.

- The correlations are improved when only uncarpeted floors are considered.

**Table 1: Correlation between one-third octave bands generated by the walker, the tire machine, the ISO machine and the NRC impactor. The correlations were calculated for all floors tested. A linear fit of the form $y = ax + b$ was assumed. $x$ represents the walker ratings and $y$ the ratings from the other device. SE denotes standard error.**

| | Tire Machine | | | | NRC Hammer | | | | ISO machine | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SE of | | | | SE of | | | | SE of | | |
| Freq | *b* | *y* | $r^2$ | *a* | *b* | *y* | $r^2$ | *a* | *b* | y | $r^2$ | *a* |
| 25 | 34.3 | 3.2 | 0.81 | 0.95 | 13.4 | 7.2 | 0.37 | 0.78 | | | | |
| 32 | 36.2 | 3.0 | 0.86 | 0.95 | 8.1 | 5.7 | 0.54 | 0.80 | | | | |
| 40 | 40.4 | 3.4 | 0.75 | 0.90 | 2.8 | 4.9 | 0.58 | 0.87 | | | | |
| 50 | 42.0 | 3.1 | 0.78 | 0.88 | 0.7 | 6.1 | 0.49 | 0.91 | 8.1 | 3.9 | 0.73 | 0.95 |
| 63 | 40.9 | 3.2 | 0.77 | 0.86 | 1.4 | 5.5 | 0.54 | 0.88 | 1.5 | 4.4 | 0.74 | 1.10 |
| 80 | 34.6 | 4.0 | 0.76 | 0.91 | -0.3 | 4.2 | 0.70 | 0.84 | 8.3 | 4.3 | 0.81 | 1.13 |
| 100 | 37.8 | 4.8 | 0.63 | 0.78 | -2.6 | 3.9 | 0.75 | 0.84 | 16.8 | 4.3 | 0.80 | 1.04 |
| 125 | 46.8 | 5.7 | 0.28 | 0.48 | 4.4 | 4.2 | 0.62 | 0.74 | 22.8 | 5.0 | 0.65 | 0.92 |
| 160 | 41.4 | 6.1 | 0.33 | 0.58 | 1.7 | 3.4 | 0.77 | 0.85 | 20.4 | 3.8 | 0.76 | 0.91 |
| 200 | 31.0 | 3.7 | 0.58 | 0.71 | 4.9 | 3.4 | 0.67 | 0.81 | 20.6 | 1.6 | 0.93 | 0.96 |
| 250 | 32.0 | 4.6 | 0.48 | 0.65 | -9.8 | 3.9 | 0.81 | 1.17 | 18.7 | 5.5 | 0.61 | 1.01 |
| 315 | 35.8 | 4.3 | 0.38 | 0.52 | -10.4 | 6.0 | 0.63 | 1.21 | 17.1 | 8.0 | 0.42 | 1.02 |
| 400 | 39.7 | 4.8 | 0.22 | 0.37 | -11.6 | 5.2 | 0.74 | 1.29 | 15.5 | 6.5 | 0.57 | 1.11 |
| 500 | 40.8 | 5.3 | 0.14 | 0.30 | -15.6 | 7.6 | 0.64 | 1.46 | -5.1 | 12.1 | 0.46 | 1.60 |
| 630 | 32.2 | 3.8 | 0.45 | 0.51 | -22.6 | 8.5 | 0.64 | 1.68 | 0.8 | 15.1 | 0.29 | 1.44 |
| 800 | 33.1 | 3.9 | 0.32 | 0.46 | -33.7 | 9.5 | 0.57 | 1.91 | -18.2 | 15.5 | 0.33 | 1.89 |
| 1000 | 37.2 | 4.1 | 0.17 | 0.30 | -14.3 | 10.0 | 0.37 | 1.25 | -6.7 | 17.6 | 0.21 | 1.48 |
| 1250 | 38.9 | 4.7 | 0.04 | 0.22 | -15.1 | 10.8 | 0.21 | 1.26 | -13.3 | 17.5 | 0.16 | 1.72 |
| TIC | -7.4 | 5.03 | 0.41 | 0.67 | -2.5 | 6.3 | 0.54 | 1.07 | | | | |
| Awt | 46.8 | 4.8 | 0.17 | 0.46 | -13.5 | 6.6 | 0.43 | 1.23 | 10.7 | 17.7 | 0.07 | 1.04 |
| IIC | | | | | | | | | 1.2 | 9 | 0.37 | 0.77 |

Table 2: Correlation between one-third octave bands generated by the walker, the tire machine, the ISO machine and the NRC impactor. The correlations were calculated for only **uncarpeted** floors. A linear fit of the form $y = ax + b$ was assumed. $x$ represents the walker ratings and $y$ the ratings from the other device. SE denotes standard error.

| | Tire Machine | | | | NRC Hammer | | | | ISO machine | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Freq | *b* | SE of *y* | $r^2$ | *a* | *b* | SE of *y* | $r^2$ | *a* | *b* | SE of *y* | $r^2$ | *a* |
| 25 | 30.4 | 3.0 | 0.85 | 1.02 | 8.6 | 3.8 | 0.76 | 0.95 | | | | |
| 32 | 34.0 | 2.2 | 0.93 | 0.98 | 9.5 | 3.2 | 0.81 | 0.83 | | | | |
| 40 | 35.7 | 2.5 | 0.87 | 0.96 | 8.0 | 2.9 | 0.77 | 0.81 | | | | |
| 50 | 38.5 | 2.5 | 0.86 | 0.93 | 5.7 | 4.8 | 0.59 | 0.85 | 7.2 | 3.7 | 0.80 | 0.98 |
| 63 | 39.3 | 2.7 | 0.85 | 0.87 | 2.6 | 4.6 | 0.66 | 0.87 | 4.0 | 3.6 | 0.82 | 1.08 |
| 80 | 31.1 | 2.5 | 0.91 | 0.95 | 2.6 | 3.7 | 0.77 | 0.80 | 13.0 | 2.8 | 0.91 | 1.04 |
| 100 | 30.7 | 3.3 | 0.85 | 0.89 | -3.9 | 3.4 | 0.83 | 0.86 | 18.4 | 3.2 | 0.88 | 1.01 |
| 125 | 30.9 | 3.6 | 0.69 | 0.80 | -0.2 | 3.4 | 0.74 | 0.83 | 21.3 | 3.3 | 0.80 | 0.95 |
| 160 | 31.3 | 4.2 | 0.65 | 0.77 | 0.8 | 2.8 | 0.84 | 0.87 | 22.6 | 2.7 | 0.85 | 0.86 |
| 200 | 31.0 | 3.7 | 0.58 | 0.71 | 4.9 | 3.4 | 0.67 | 0.81 | 20.6 | 1.6 | 0.93 | 0.96 |
| 250 | 29.5 | 4.3 | 0.55 | 0.70 | -7.5 | 3.2 | 0.85 | 1.13 | 26.2 | 2.2 | 0.87 | 0.85 |
| 315 | 33.6 | 4.4 | 0.43 | 0.56 | -2.7 | 3.0 | 0.86 | 1.06 | 26.2 | 3.1 | 0.78 | 0.86 |
| 400 | 34.7 | 4.6 | 0.33 | 0.49 | -1.5 | 3.7 | 0.78 | 1.06 | 29.7 | 3.3 | 0.72 | 0.79 |
| 500 | 37.4 | 5.3 | 0.21 | 0.38 | 1.3 | 3.8 | 0.81 | 1.07 | 23.1 | 4.4 | 0.71 | 0.96 |
| 630 | 29.3 | 3.6 | 0.54 | 0.58 | -4.0 | 3.6 | 0.84 | 1.24 | 37.8 | 5.2 | 0.36 | 0.56 |
| 800 | 26.6 | 3.7 | 0.46 | 0.63 | -17.1 | 7.1 | 0.58 | 1.52 | 24.1 | 6.2 | 0.37 | 0.87 |
| 1000 | 33.7 | 3.8 | 0.31 | 0.40 | -8.6 | 8.7 | 0.42 | 1.18 | 24.4 | 7.3 | 0.33 | 0.81 |
| 1250 | 32.0 | 4.7 | 0.15 | 0.45 | -8.6 | 10.6 | 0.19 | 1.16 | 20.2 | 8.9 | 0.17 | 0.91 |
| TIC | -13.1 | 4.6 | 0.52 | 0.77 | -2.6 | 4.8 | 0.66 | 1.04 | | | | |
| Awt | 39.7 | 4.6 | 0.30 | 0.60 | -11.1 | 4.7 | 0.63 | 1.22 | | | | |
| IIC | | | | | | | | | 28.2 | 11.9 | 0.10 | 0.77 |
| | | | | | | | | | -3.0 | 5.8 | 0.55 | 0.79 |

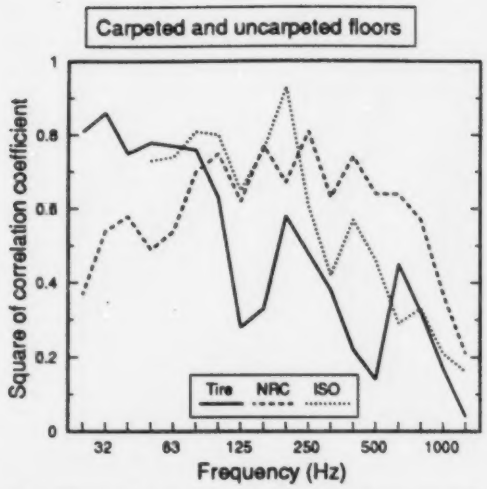


*Figure 10: Plot of square of correlation coefficient for each frequency for the Tire machine and the ISO machine. Carpeted and uncarpeted floors.*

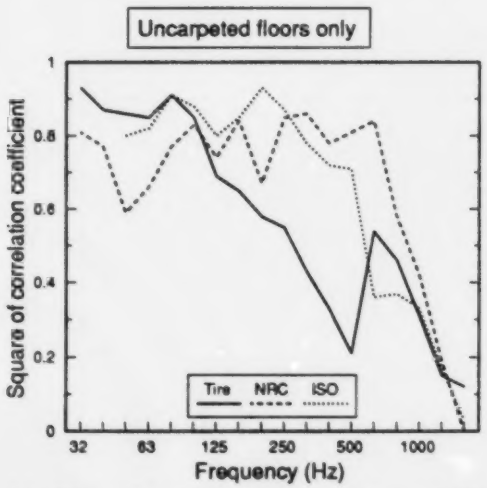


*Figure 11: Plot of square of correlation coefficient for each frequency for the Tire machine and the ISO machine. Uncarpeted floors only*

*Correlations Between Single Number Ratings*

Initially, the single number ratings used were those based on established national and international standards: the impact insulation class (IIC), A-weighted levels and the tire impact class (TIC). TIC, explained in Appendix B, is a modification of the single number rating used in the Japanese test. An IIC rating was also calculated for the walker data so comparisons could be

made with the ISO machine data. Tables 1 and 2 show the correlation between these ratings for the impactors used. The tables show that

- A-weighted levels do not correlate well because of the differences in spectrum level at the higher frequencies. The A-weighting network emphasizes the levels around 2000 Hz and attenuates the levels at low frequencies.
- The tire impact class (TIC) ratings do not correlate well because of spectral differences around 500 Hz. In many cases the TIC for the tire was determined by the levels around 50 Hz while the TIC for the walker was determined by the levels at much higher frequencies. Figure 12 shows an example of this.
- The impact insulation class (IIC) rating for the ISO machine, does not correlate well with that for the walker. The ISO machine has been criticized because the single number ratings used previously do not correlate well with subjective reactions to impact sound transmitted through floor systems. These data support that contention.

Thus despite the fairly good correlation in individual frequency bands, these single number ratings are not adequate.

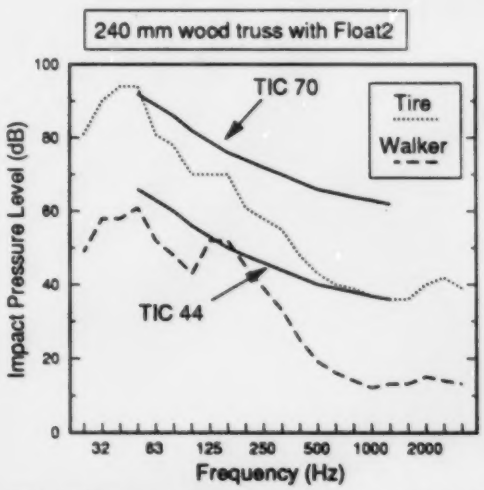


*Figure 12: Fitting of TIC contour to tire and walker data. The same floor was being measured in each case. The TIC ratings are determined by different parts of the spectrum.*

*Possible New Single Number Ratings*

The common criticisms of the IIC rating are

- it does not correlate well with subjective reactions

- it places too much importance on high frequencies and not enough on low frequencies.

Other authors have considered other single number rating systems for use with the ISO tapping machine. Other single number rating procedures examined in this work included:

- C-weighted levels — the energy sum of all the measured levels
- The maximum level measured
- The level of the total energy from 50 to 500 Hz
- A rating similar to one proposed by Bodlund[7]. This uses the same general fitting procedures used in determining IIC, but the frequency ranges from 50 to 500 Hz and the contour is a different shape (it increases 1 dB for each one-third-octave band increase in frequency). Bodlund's contour extended to 1000 Hz. The rating is here called BIC (Bodlund impact class). An example of a test result and the fitted BIC contour is shown in Figure 13.

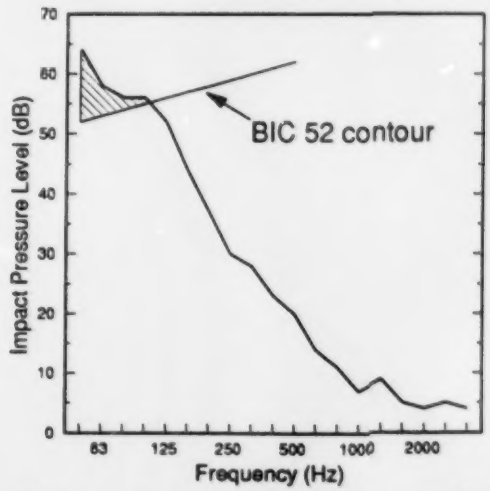


*Figure 13: An example of the BIC contour fitted to tapping machine data. Data from 50 to 500 Hz are used. The sum of the deficiencies (shaded area) must not be greater than 22. The BIC value is given by the contour level at 50 Hz.*

The good correlations between the ISO machine and the walker one-third octave levels suggest that if the spectra from the ISO machine were treated differently, the single number ratings calculated would correlate better with walker ratings. One way of doing this is to consider other reference contours as was done by Bodlund [7].

Instead of using a contour fitting procedure like those for IIC, TIC and BIC, the procedure that was adopted here was to "correct" the spectrum for all tapping machine tests and calculate a weighted level — a summation of energy. The mean spectra for walker and tapping machine tests were calculated. The difference between the two mean spectra was used to generate corrections to add to the levels measured with the ISO machine. The differences were rounded to the nearest 5 dB. This weighting was needed only at the lower frequencies. Table 3 shows the values that were added to the measured levels in the bands from 50 to 100 Hz. Once these values were added to the measured spectra, new single number ratings were calculated. The set of increments shown is the weighting that was judged to be most appropriate. Two others were investigated but gave no significant difference improvement.

Table 3 Increments added to ISO machine levels to improve correlation of single number ratings with walker ratings.

| Frequency | Increment |
|---|---|
| 50 | 15 |
| 63 | 15 |
| 80 | 10 |
| 100 | 5 |

A more thorough analysis to optimize these increments and derive an alternative single number rating would require much more computation. While this could be done, it is not likely that the correlations would be greatly improved because of the variability inherent in the walker data.

The new correlations calculated are shown in Table 4. Ideally one would like to see $r^2$ and the coefficient $a$ close to 1, and the two standard error terms close to zero. The closer this ideal is approached, the better the machine rating will predict the walker rating. The table shows two sets of correlation data: one for all floors tested and the other for floors without carpets.

Table 4: Correlations with walker single number ratings. A linear fit of the form $y = ax + b$ was assumed. $x$ represents the walker ratings and $y$ the ratings from the other device. SE denotes standard error.

**All 75 floors, including carpets**

ISO machine

| | $r^2$ | $a$ | $b$ | SE of $y$ | SE of $a$ |
|---|---|---|---|---|---|
| C | 0.37 | 1.00 | 4.9 | 7.3 | 0.15 |
| Max | 0.40 | 0.99 | 3.6 | 6.9 | 0.14 |
| BIC | 0.47 | 1.01 | 10.65 | 7.34 | 0.13 |
| 50-500 | 0.50 | 0.97 | 9.1 | 6.5 | 0.11 |

Tire

| | | | | | |
|---|---|---|---|---|---|
| C | 0.75 | 0.92 | 39.1 | 3.0 | 0.06 |
| Max | 0.71 | 0.88 | 41.8 | 3.3 | 0.07 |
| BIC | 0.66 | 0.79 | 42.9 | 3.8 | 0.07 |
| 50-500 | 0.76 | 0.87 | 41.9 | 3.2 | 0.06 |

ISO machine, weighted spectrum

| | | | | | |
|---|---|---|---|---|---|
| C | 0.59 | 1.27 | -3.5 | 6.0 | 0.12 |
| Max | 0.60 | 1.26 | -0.9 | 5.9 | 0.12 |
| BIC | 0.76 | 1.3 | -2.3 | 5.0 | 0.1 |
| 50-500 | 0.73 | 1.22 | 3.8 | 4.9 | 0.09 |

**51 Floors without carpets**

ISO machine

| | | | | | |
|---|---|---|---|---|---|
| C | 0.44 | 0.92 | 12.6 | 5.7 | 0.15 |
| Max | 0.35 | 0.87 | 12.8 | 6.5 | 0.17 |
| BIC | 0.64 | 0.85 | 22.1 | 4.3 | 0.09 |
| 50-500 | 0.59 | 0.87 | 18.0 | 4.8 | 0.10 |

Tire

| | | | | | |
|---|---|---|---|---|---|
| C | 0.89 | 1.04 | 30.3 | 2.0 | 0.05 |
| Max | 0.85 | 1.01 | 32.7 | 2.3 | 0.06 |
| BIC | 0.77 | 0.87 | 37.4 | 3.2 | 0.07 |
| 50-500 | 0.87 | 0.93 | 37.1 | 2.4 | 0.05 |

ISO machine, weighted spectrum

| | | | | | |
|---|---|---|---|---|---|
| C | 0.60 | 1.2 | 2.2 | 5.4 | 0.14 |
| Max | 0.59 | 1.2 | 4.5 | 5.5 | 0.14 |
| BIC | 0.84 | 1.3 | 0.0 | 3.8 | 0.08 |
| 50-500 | 0.78 | 1.1 | 10.4 | 4.0 | 0.09 |

Examination of this table shows that the ratings calculated from the unweighted spectra from the ISO machine do not correlate well with those from the walker data. This is true for the complete set of data and for the set restricted to floors without carpets. Although, in the latter case the BIC rating gives fair correlation.

For the tire machine, the C, Max and 50-500 ratings correlate well with the corresponding walker ratings. The values for the standard error of $y$ are fairly small too.

The weighted ISO machine spectra give ratings that correlate quite well with the walker ratings. Generally the values for the standard error of $y$ are greater than those for the tire ratings and the $r^2$ values are slightly less.

To illustrate the relationships between ratings, some of them are plotted in Figures 14 to 16.

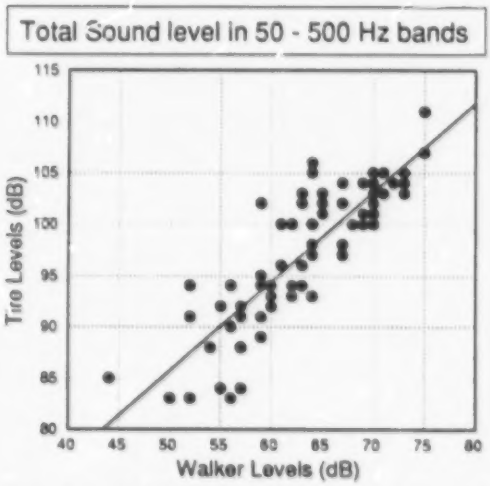


*Figure 14: Sum of energy in bands 50 to 500 Hz. Tire data vs. walker data. All floors included, $r^2 = 0.76$.*

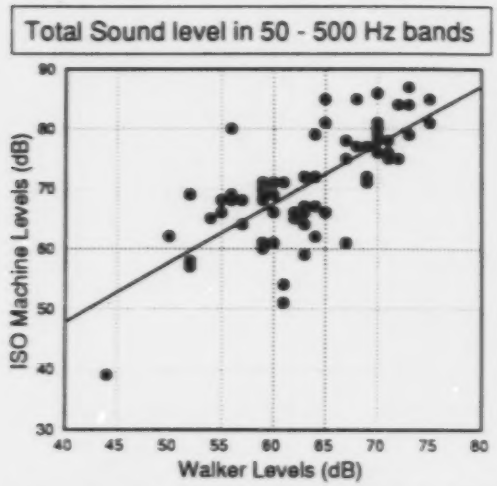


*Figure 15: Sum of energy in bands 50 to 500 Hz. ISO machine data vs. walker data. All floors included, $r^2 = 0.5$.*

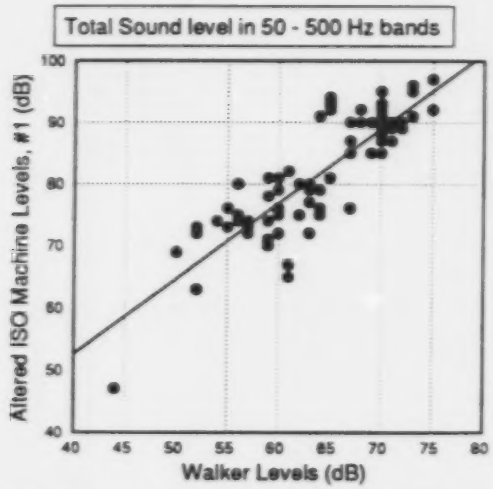


*Figure 16: Sum of energy in bands 50 to 500 Hz. Weighted spectra from ISO machine vs. walker data. All floors included, $r^2 = 0.73$.*

The values of the correlation coefficients in the table confirm some of the opinions about the ISO Tapping machine. When all frequencies are included to calculate a rating, the high frequencies are given too much weight and correlation with the walker ratings is reduced. Conversely, when the low frequencies are emphasized, the correlations are improved. Once again, excluding carpeted floors, improves the correlation with the walker data.

*Possibilities for New Test Procedure*

On the basis of correlations alone, one might choose the tire machine for evaluating floor systems. The correlation coefficients are higher and the standard errors of $y$ are usually smaller than those for the ISO machine. There are, however, other considerations.

- The Rion tire machine is expensive. Tires could be dropped manually but this decreases the precision of the test and makes field measurement more difficult.
- The blows from the tire are rather violent even with the reduced drop height used in this work. This makes the tire machine less attractive for use in furnished homes.
- Many laboratories and consultants already have standard ISO tapping machines. A new test procedure based on the present machine would present little hardship and should get little opposition.
- A large body of test data from the tapping machine already exists. Some of it extends to lower frequencies and could be reprocessed to give improved single number ratings for floor systems that have been tested in the past.
- The differences between the correlation coefficients for the ISO machine ratings and those for the tire machine are not very significant.

**Considering all factors, it appears that there is no need to introduce a new standardized test based on a tire drop. The standard tapping machine can be used for measurements at lower frequencies and a more appropriate single number rating is feasible.**

Bodlund came to a similar conclusion; the ISO machine can be used to give single number ratings that correlate well with occupant satisfaction. The single number rating he recommended does not, however, work as well in this study as some of those discussed above. This set of data was obtained in one laboratory only and with one floor size. It is possible that different floor sizes would give different results, perhaps with less energy at 50 Hz. This might explain why Bodlund found that there was no benefit to increasing the weighting of the ISO machine data below 100 Hz; normal sized floors in homes may not show the same peak at 50 Hz. Further research work is needed to address this issue.

The final decisions on whether or how to proceed with a new standard tapping machine or tire test will rest with the appropriate standards committees — ASTM E33 and ISO TC43 SC2.

*Criteria for Multi-family Homes*

The study carried out by Bodlund in 22 different apartments gives information that allows estimation of impact noise criteria for use in multi-family homes. In that work he found that a subjective score of 4.4 corresponded to about 51% of occupants judging the impact sound insulation as good or very good. Alternatively, more than 20% of the persons interviewed judged the impact sound insulation as quite unsatisfactory. This subjective score of 4.4 was taken as indicating an acceptable construction.

Bodlund gave a relationship between $L'_{n,w}$, the ISO R717 single number rating for impact noise transmission[8], and the subjective score S as

$$L'_{n,w} = 80.6 - 5.48\ S\ (r^2 = 0.56,\ n = 22).$$

The relation he found between his BIC (called $I_s$ in his paper) and S was

$$BIC = 86.3 - 5.53\ S\ (r^2 = 0.76,\ n = 22).$$

IIC is approximately related to $L'_{n,w}$ by $IIC = 110 - L'_{n,w}$. Thus, according to Bodlund's criterion of S = 4.4, for user satisfaction the IIC should be greater than 54. This figure agrees very well with the recommendation of IIC 55 for a bare floor that is commonly used in Canada. The corresponding BIC rating is 62.

Using the data collected in the present work, relationships can be found between BIC and the 50-500 Hz ratings for the ISO machine and for the weighted ISO machine spectra. These are

$$(BIC)_{wt} = 0.82\ BIC + 14.3\ (r^2 = 0.63,\ n = 75)$$

and

$$(50\text{-}500)_{wt} = 0.75\ BIC + 34.6\ (r^2 = 0.64,\ n = 75).$$

It is somewhat risky to use these equations to estimate what acceptable ratings for $(BIC)_{wt}$ and $(50\text{-}500)_{wt}$ would be. There is, however, no other way at the moment. Substituting BIC = 62 in these equations gives $(BIC)_{wt} = 65$ and $(50\text{-}500)_{wt} = 81$. Note that all of these ratings, with the exception of IIC, get *smaller* as the impact sound insulation of the floor *improves*.

How many of the floors tested met these criteria? Of the 75 floors tested, 39 of them had IIC values of 55 or more. Of the 51 uncarpeted floors tested, only 19 of them had an IIC of 55 or more. Using the 50-500 Hz rating and the criterion that it should be 80 or less, the corresponding numbers are 40 and 26. The kinds of floors that were satisfactory are discussed in the next section.

# Floor Sound Transmission

## Summary of tests

This project had the primary goal of investigating the possibilities of creating a new impact test. Inevitably, because of the experimental design, a large amount of sound transmission information was collected. A thorough analysis of this data set to explain each feature of each test, is beyond the scope of this report. This section therefore presents a summary of the data with limited comment on the significance.

In the tables that follow, floor systems are identified by names such as Joist1. The full description of each floor type can be found in Appendix C. The floor coverings are identified as C and CU for carpet, carpet and underpad. The floating floors are identified as F1, F2, and F3 for Float1, Float2, and Float3. Descriptions of these coverings and floating floors are also in Appendix C.

Table 5 shows impact insulation class (IIC) for the basic floors tested with and without the five standard toppings.

Table 5: IIC Ratings

| | Bare | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|---|
| Joist1 | 51 | 65 | 80 | | | |
| Joist2 | 44 | | | 57 | 58 | 51 |
| Joist2 + 40 mm concrete | 40 | 73 | 84 | | | |
| Truss1-w | 41 | 48 | 65 | 55 | 55 | 47 |
| Truss1 | 40 | 47 | 66 | 52 | 52 | 46 |
| Truss2 | 48 | 57 | 72 | 59 | 60 | 50 |
| Truss3 | 49 | 57 | 70 | 55 | 59 | 51 |
| 150 mm concrete | 25 | 68 | 86 | 71 | 64 | 63 |
| Djoist1 | 56 | 64 | 81 | | | |
| Djoist1 + 40 mm concrete | 63 | | | | | |
| Djoist2 | 54 | | | | | |
| Djoist2 + 40 mm concrete | 59 | | | | | |
| Djoist3 | 52 | | | | | |

Table 6 shows the sound transmission class (STC) ratings for the same floors. Close examination of this table reveals some puzzling results. The addition of a layer of 40 mm of concrete directly on top of Djoist1 and Djoist2 results in relatively small increases in STC. The reasons for this have yet to be clearly established, but one disturbing explanation is that an STC of 62 is about the

limit that can be measured in the existing floor test facility because of flanking sound transmission.

Floors installed for testing are supported on steel supports that are attached to the upper test room — the source room. It is therefore possible for airborne sound to flow from the source room floor into the test floor structure. This flanking path bypasses any floating floor structure that rests on the test floor. This possible flanking path was identified before the project began. Specimens were carefully installed resting on resilient pads and not touching the upper test room floor. Despite this care, there still seems to be some flanking transmission. Note, however, that this flanking has minimal effect on impact sound transmission because the impacts are directly on the surface of the floating slab. Any transmission of energy from the test floor to the floor of the source room represents some additional damping which would be constant for a particular floor structure and would be similar to the structural damping present in buildings. *Thus, we do not believe that the impact test measurements were significantly compromised.*

While this flanking is a serious problem for IRC, it will be resolved soon by the commissioning of the new floor test facility. We will then repeat some of the work we have done here. A more practical question is: "Can values greater than these be readily achieved in real buildings?" This is not easy to answer because few buildings in Canada are constructed to have very high airborne sound insulation values.

Table 6: STC ratings

| | Bare | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|---|
| Joist1 | 55 | 58 | 58 | | | |
| Joist2 | 49 | | | 60 | 59 | 57 |
| Joist2 + 40 mm concrete | 59 | 59 | 58 | | | |
| Truss1-w | 51 | 52 | 52 | 60 | 59 | 58 |
| Truss1 | 48 | 50 | 50 | 60 | 60 | 55 |
| Truss2 | 55 | 57 | 56 | 62 | 62 | 60 |
| Truss3 | 54 | 56 | 56 | 60 | 60 | 57 |
| 150 mm concrete | 52 | 52 | 51 | 62 | 62 | 61 |
| Djoist1 | 59 | 59 | 59 | | | |
| Djoist1 + 40 mm concrete | 61 | | | | | |
| Djoist2 | 57 | | | | | |
| Djoist2 + 40 mm concrete | 61 | | | | | |
| Djoist3 | 55 | | | | | |

In the previous major section, alternative ratings for impact sound were considered. One that worked fairly well with the data collected was the total energy in the bands 50 to 500 Hz. The next three tables show this rating for

the weighted spectrum for the ISO machine, the tire machine and the walker. Note that this rating, unlike STC and IIC decreases as the sound insulation improves.

Table 7: 50-500 ratings for weighted ISO spectra

| | Bare | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|---|
| Joist1 | 90 | 85 | 72 | | | |
| Joist2 | 97 | | | 75 | 74 | 85 |
| Joist2 + 40 mm concrete | 76 | 76 | 65 | | | |
| Truss1-w | 90 | 85 | 70 | 79 | 78 | 87 |
| Truss1 | 96 | 91 | 75 | 79 | 79 | 87 |
| Truss2 | 93 | 90 | 76 | 75 | 75 | 87 |
| Truss3 | 91 | 89 | 79 | 81 | 81 | 89 |
| 150 mm concrete | 80 | 63 | 47 | 72 | 74 | 74 |
| Djoist1 | 82 | 80 | 72 | | | |
| Djoist1 + 40 mm concrete | 69 | | | | | |
| Djoist2 | 90 | | | | | |
| Djoist2 + 40 mm concrete | 76 | | | | | |
| Djoist3 | 92 | | | | | |

Table 8: 50-500 ratings for Tire machine

| | Bare | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|---|
| Joist1 | 98 | 100 | 102 | | | |
| Joist2 | 111 | | | 94 | 94 | 103 |
| Joist2 + 40 mm concrete | 98 | 97 | 96 | | | |
| Truss1-w | 104 | 104 | 102 | 92 | 89 | 102 |
| Truss1 | 103 | 104 | 105 | 93 | 94 | 103 |
| Truss2 | 105 | 105 | 106 | 93 | 93 | 103 |
| Truss3 | 105 | 103 | 102 | 94 | 94 | 102 |
| 150 mm concrete | 83 | 83 | 85 | 94 | 84 | 88 |
| Djoist1 | 96 | 94 | 94 | | | |
| Djoist1 + 40 mm concrete | 83 | | | | | |
| Djoist2 | 100 | | | | | |
| Djoist2 + 40 mm concrete | 84 | | | | | |
| Djoist3 | 100 | | | | | |

| Table 9: 50-500 ratings for Walker | | | | | | |
|---|---|---|---|---|---|---|
| | Bare | C | CU | F1 | F2 | F3 |
| Joist1 | 67 | 69 | | | | |
| Joist2 | 75 | | | 56 | 59 | 70 |
| Joist2 + 40 mm concrete | 64 | 67 | 61 | | | |
| Truss1-w | 72 | 67 | 59 | 60 | 59 | 67 |
| Truss1 | 73 | 70 | 64 | 64 | 63 | 71 |
| Truss2 | 70 | 71 | 64 | 62 | 60 | 70 |
| Truss3 | 73 | 71 | 63 | 59 | 60 | 70 |
| 150 mm concrete | 56 | 52 | 44 | 63 | 57 | 54 |
| Djoist1 | 61 | 62 | 52 | | | |
| Djoist1 + 40 mm concrete | 50 | | | | | |
| Djoist2 | 68 | | | | | |
| Djoist2 + 40 mm concrete | 55 | | | | | |
| Djoist3 | 70 | | | | | |

### Improvements for floor toppings

Frequently, the improvement that can be expected due to a floor topping is of interest. The following tables were generated to show improvements due to the five toppings used. The same single number ratings are used as in the previous section.

Table 10 shows improvements in IIC rating. From this table one can see that the addition of a soft floor covering or a floating slab does not always give the same improvement for all floor types. If, however, floors of the same general type are considered, the improvement is roughly the same. For example, adding carpet to a wood joist structure improves IIC by about 8 in most cases, a carpet and underpad improves IIC by about 25, and Float1 and Float2 improve the IIC by about 12 points. There are some deviations but these are useful approximations.

| Table 10: Improvement in IIC Ratings relative to the bare floor | | | | | |
|---|---|---|---|---|---|
| | C | CU | F1 | F2 | F3 |
| Joist1 | 14 | 29 | | | |
| Joist2 | | | 13 | 14 | 7 |
| Joist2 + 40 mm concrete | 33 | 44 | | | |
| Truss1-w | 7 | 24 | 14 | 14 | 6 |
| Truss1 | 7 | 26 | 12 | 12 | 6 |
| Truss2 | 9 | 24 | 11 | 12 | 2 |
| Truss3 | 8 | 21 | 6 | 10 | 2 |
| 150 mm concrete | 43 | 61 | 46 | 39 | 38 |
| Djoist1 | 8 | 25 | | | |

Table 11 shows improvements in STC. Again similar rules of thumb can be found for the improvement due to a particular topping on a type of floor.

| Table 11: Improvement in STC ratings relative to the bare floor | | | | | |
|---|---|---|---|---|---|
| | C | CU | F1 | F2 | F3 |
| Joist1 | 3 | 3 | | | |
| Joist2 | | | 11 | 10 | 8 |
| Joist2 + 40 mm concrete | 0 | -1 | | | |
| Truss1-w | 1 | 1 | 9 | 8 | 7 |
| Truss1 | 2 | 2 | 12 | 12 | 7 |
| Truss2 | 2 | 1 | 7 | 7 | 5 |
| Truss3 | 2 | 2 | 6 | 6 | 3 |
| 150 mm concrete | 0 | -1 | 10 | 10 | 9 |
| Djoist1 | 0 | 0 | | | |

In the previous major section, some of the inadequacies of the IIC rating were discussed. These, of course, were the main reason why the project was started. In the following tables, the 50-500 Hz differences are presented. Because of the nature of this rating, negative numbers mean a reduction in noise transmission.

Table 12: Improvement in 50-500 ratings for weighted ISO spectra relative to the bare floor

| | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|
| Joist1 | -5 | -18 | | | |
| Joist2 | | | -22 | -23 | -12 |
| Joist2 + 40 mm concrete | 0 | -11 | | | |
| Truss1-w | -5 | -20 | -11 | -12 | -3 |
| Truss1 | -5 | -21 | -17 | -17 | -9 |
| Truss2 | -3 | -17 | -18 | -18 | -6 |
| Truss3 | -2 | -12 | -10 | -10 | -2 |
| 150 mm concrete | -17 | -33 | -8 | -6 | -6 |
| Djoist1 | -2 | -10 | | | |

Table 13: Improvement in 50-500 ratings for Tire machine relative to the bare floor

| | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|
| Joist1 | 2 | 4 | | | |
| Joist2 | | | -17 | -17 | -8 |
| Joist2 + 40 mm concrete | -1 | -2 | | | |
| Truss1-w | 0 | -2 | -12 | -15 | -2 |
| Truss1 | 1 | 2 | -10 | -9 | 0 |
| Truss2 | 0 | 1 | -12 | -12 | -2 |
| Truss3 | -2 | -3 | -11 | -11 | -3 |
| 150 mm concrete | 0 | 2 | 11 | 1 | 5 |
| Djoist1 | -2 | -2 | | | |

Table 14: Improvement in 50-500 ratings for Walker relative to the bare floor

| | C | CU | F1 | F2 | F3 |
|---|---|---|---|---|---|
| Joist1 | 2 | | | | |
| Joist2 | | | -19 | -16 | -5 |
| Joist2 + 40 mm concrete | 3 | -3 | | | |
| Truss1-w | -5 | -13 | -12 | -13 | -5 |
| Truss1 | -3 | -9 | -9 | -10 | -2 |
| Truss2 | 1 | -6 | -8 | -10 | 0 |
| Truss3 | -2 | -10 | -14 | -13 | -3 |
| 150 mm concrete | -4 | -12 | 7 | 1 | -2 |
| Djoist1 | 1 | -9 | | | |

## Some specific cases

*Adding concrete directly to a joist floor*

Some interesting questions can be answered using the data collected. For example, concrete toppings are often used to improve the sound insulation of wood joist or truss floors. Table 15 summarizes results for the two cases that were measured. In one case the increase in STC is about 10, in the other only 2. This latter small difference is taken to be an indication of the flanking transmission in the laboratory that was discussed earlier. It was pointed out above that the possible flanking path will not influence the impact sound ratings. It certainly will not invalidate conclusions drawn about correlations between single number ratings. The 50-500 Hz ratings in this table give a fairly consistent picture but the STC and IIC ratings do not.

Table 15: Effect of adding concrete directly on joist floor

| | | | (50-500) ratings | | |
|---|---|---|---|---|---|
| Floor | STC | IIC | $ISO_{wt}$ | Tire | Walker |
| Joist2 | 49 | 44 | 97 | 111 | 75 |
| Joist2 + 40 mm concrete | 59 | 40 | 76 | 98 | 64 |
| Difference | 10 | -4 | -21 | -13 | -11 |
| Djoist1 | 59 | 56 | 82 | 96 | 61 |
| Djoist1 + 40 mm concrete | 61 | 63 | 69 | 83 | 50 |
| Difference | 2 | 7 | -13 | -13 | -11 |

*Differences between floating floor types.*

The difference tables above allow one to draw some conclusions about the types of floating floors used. Float1 and Float2 used a 40 mm concrete slab with two different methods for support. They give about the same single number ratings. Float3 used a 16 mm plywood raft and was clearly less effective.

*Effect of truss depth*

One factor that was varied in the measurements was the depth of the wood trusses used. Two effects should be at work here: 1) as the cavity depth increase, the sound insulation is expected to increase, and 2) as the truss depth increases the floor stiffness increases. This should result in less impact sound. Table 16 shows results for the joist floors and the truss floors tested. The double joist system is included in this table for interest although

it is not a fair comparison. The trends are not very marked, but there is a tendency toward improved insulation as the cavity and joist depth increases. The double joist system with its extra layers of material and superior isolation between the floor and ceiling system, is noticeably better.

Table 16: Effect of truss depth on floor sound transmission (Joist depth shown in mm)

| Floor | (50-500) ratings STC | IIC | $ISO_{wt}$ | Tire | Walker |
|---|---|---|---|---|---|
| Joist2 (240) | 49 | 44 | 97 | 111 | 75 |
| Truss1-w (240) | 50 | 41 | 90 | 104 | 72 |
| Truss1 (240) | 48 | 40 | 96 | 103 | 73 |
| Truss2 (300) | 55 | 48 | 93 | 105 | 70 |
| Truss3 (400) | 54 | 49 | 91 | 105 | 73 |
| Djoist1 (430) | 59 | 56 | 82 | 96 | 61 |

*Effect of sound absorbing material in floating floor cavity*

The 150 mm concrete slab was tested with Float2 with and without the sound absorbing material in the cavity. Table 17 shows the results. The IIC ratings are increased. The other ratings do not show any clear improvement.

Table 17: Effect of adding sound absorbing material in cavity of Float2 and of increasing cavity depth in Float3

| Floor | (50-500) ratings STC | IIC | $ISO_{wt}$ | Tire | Walker |
|---|---|---|---|---|---|
| 150 mm concrete slab Bare | 52 | 25 | 80 | 83 | 56 |
| 40 mm concrete on 21 mm thick neoprene pads | 61 | 57 | 72 | 88 | 57 |
| 40 mm concrete on 21 mm thick neoprene pads with AF331 in cavity | 62 | 64 | 74 | 84 | 57 |
| Float3 | 61 | 63 | 74 | 88 | 54 |
| Float3 but with strapping increased to 80 mm thick | 62 | 66 | 71 | 95 | 59 |

*Effect of depth of floating floor cavity*

Table 17 also shows the effect of increasing the thickness of the wood strapping under the 16 mm plywood used in Float3. The ratings from the tapping machine show an improvement; those from the tire and the walker do not.

*Effect of stiffness of floating floor support pads.*

At one point in the measurements, several different types of support pads were used. The stiffness of these pads is given in Table 18

Table 18: Stiffness of floating floor support pads.

| Material | Stiffness (N/m) |
|---|---|
| Hard rubber blocks | 61217 |
| Brown composite damping material (CDM) | 57500 |
| Neoprene Lab Stoppers, 18 mm thick | 44500 |
| Green CDM | 32100 |
| Neoprene Foam, 21 mm thick | 14500 |
| AF530 | 4250 |
| AF570 | 5700 |

These supports were placed under the concrete slab in a standard pattern. The 21 mm thick neoprene foam pads were used as standard under Float2. Table 19 shows the results. As the stiffness decreases, the IIC ratings improve. There is no clear improvement seen with the other rating systems.

Table 19: Effect of different support pads on sound transmission. Basic floor is Joist2. The slab is the 40 mm concrete layer.

| Pads | STC | IIC | (50-500) ratings $ISO_{wt}$ | Tire | Walker |
|---|---|---|---|---|---|
| Hard rubber blocks, standard pattern | 58 | 46 | 74 | 90 | 56 |
| Hard rubber blocks, on joists | 59 | 48 | 73 | 91 | 57 |
| Hard rubber blocks, between joists | 59 | 48 | 73 | 91 | 52 |
| Brown CDM | 59 | 48 | 73 | 92 | 55 |
| Neoprene Lab Stoppers, 18 mm thick | | | | | |
| Green CDM | 59 | 54 | 74 | 90 | 56 |
| Neoprene Foam, 21 mm thick | 58 | 55 | 74 | 92 | 57 |
| AF530 | 60 | 57 | 75 | 94 | 56 |

*Effect of position of pads supporting the floating floor with joist floors*

Also shown in Table 19 are the results found when the support pads were moved so all were directly on a joist or all between joists. There was no effect on the single number ratings.

# Appendix A
# Measurement Procedures

## Airborne Sound Transmission

Airborne sound transmission tests were conducted in accordance with the requirements of ASTM E90 [5], Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions. The Sound Transmission Class was determined in accordance with ASTM Standard Classification E413[8]. The upper room is the source room and has a volume of 120 $m^3$. The lower room, the receiving room, has a volume of 65 $m^3$. The floor opening measures 2.44 × 2.44 m for an area of 5.9 $m^2$. Each room has four independent loudspeaker systems to generate sound. Mean sound pressure levels are measured at nine fixed locations in each room using movable microphones controlled by computer. Measurements were made in one-third octave bands from 63 to 6300 Hertz. For the tapping machine tests, the 50 Hz band was added in the later stages of the project.

## Tapping Machine Impact Sound Transmission

Tapping machine impact tests were conducted in accordance with the requirements of ASTM E492. Impact Insulation Class was determined in accordance with ASTM Classification E989. The lower room was the receiving room and has a volume of 65 $m^3$. Measurements were made in one-third octave bands from 63 to 6300 Hertz initially but later extended to 50 Hz.

## Measurement of Maximum Impulsive Sound Levels

A Nortronics 830 real-time analyzer was used to measure peak sound pressure levels generated by the Tire machine as well as the walker and the NRC impactor. The receiving room below the floor had sound absorbing material placed in it to reduce the reverberant field there. A single microphone place 1 m from the underside of the ceiling was used to measure the peak levels. The analyzer was set to have a 35 ms time constant and the maximum levels recorded during a time of 1 second were passed to the controlling computer. 10 peak readings were taken at five positions of the impactor on the floor. These positions are shown in Appendix B. The positions used for the NRC impactor were the same as those used for the Tire machine. Measurements were made in one-third octave bands from 25 to 6300 Hertz. Means and standard deviations were calculated.

The male walker weighed 81.8 to 84 kg during these tests and walked in a random combination of circles and figure-of-eight patterns on the floor. The same pair of medium-weight shoes was worn for each test. These had leather soles and heels with a hard rubber tip on the heels.

# Appendix B
# Development of Tire Drop Test

**Summary of Appendix B**

This research project aimed to develop a test for evaluating the transmission of low-frequency impact sounds through lightweight floor constructions typical of those used in Canadian construction. The proposed test procedure used a modified version of an existing Japanese standard.

The Japanese test method [1] uses a small automobile tire and wheel as the impactor. The tire weight, pressure and drop height control the force imparted to the floor. The force generated controls the peak impact sound pressure level created in the room below the floor under test.

This Appendix provides a summary of work done to evaluate the modified tire test. It describes preliminary measurements made using a force plate to calibrate the force pulse. The measurements allowed an examination of the influence of factors such as tire inflation pressure and drop height on the measured forces. Changes to the acoustical test procedures and the resulting changes in peak impact sound pressure levels were also examined. The work in this Appendix shows the following:

- with a single fixed microphone position, impacts close to the center of the floor generate more noise than those close to the edge;
- there was no significant change in peak impact sound pressure level when the impact position was changed from directly on a joist to between the joists;
- the presence of one or two people on a wood joist floor had no significant effect on measured peak sound pressure levels;
- a cluster of positions close to the floor center gives highest impact sound pressure levels and thus a conservative estimate of the ability of the floor to reduce the transmission of low-frequency sound;
- the repeatability of the test procedure is good;
- changes of inflation pressure and drop height for the tire within the limits proposed for the standard do not produce large changes in measured sound levels;
- a microphone position 1 m below the middle of the ceiling is expected to reduce the effect of the room. Measurements will represent mainly the floor behavior.

# Development of Tire Drop Test

To deal with the problems of footstep noise on lightweight floors, the Japanese standards organization (JIS) developed an additional test procedure. This is used as well as the tapping machine test. A small automobile tire is dropped from a height of 0.9 m on to the floor under test, and sound pressure levels are measured in the room below. This test method has some deficiencies that would make it unsuitable for use in Canada. In particular:

- the drop height is too great; the blows on lightweight floors are violent, creating a risk of damage especially in furnished homes;
- operators must measure at many positions throughout the test room. This makes the test procedure lengthy. As well, the low-frequency response of the room probably will adversely influence test reproducibility;
- the time constant used in signal analysis is 125 ms. More modern instruments use 35 ms to better simulate ear response.

Most of the energy generated by this impactor is at low frequencies. Research at NRC and in other laboratories and field experience with impact noise transmission showed the importance of low-frequency impact noise and suggested the need for new test procedures to deal with this problem.

## Modifications Proposed By ASTM Task Group

To make the Japanese tire test more suitable for use in North American building codes, the task group of ASTM committee E33.03 suggested the following modifications to JIS 1418:

- a reduced drop height;
- the use of a single microphone 1 m below the ceiling instead of several microphone positions;
- use of a time constant of 35 ms for analysis (this gives a better simulation of ear response than the JIS test);
- random positions for impact instead of only five positions (gives improved sampling of the floor).

These and other changes were investigated during the preliminary study and are discussed later.

## The "Bang" Machine: Basic Properties

The Rion company in Japan manufactures a machine that delivers a force meeting the requirements of JIS 1418. A sketch of the "Bang" machine used for this project is shown at the beginning of this report. A motor and cam system lift the arm and tire from the floor. At the top of the swing, the arm is released to fall under gravity. The tire, wheel rim, and lifting arm form the impacting object.

## Simple Tire and Wheel

The Bang machine is expensive and difficult to transport. A small tire and wheel that could be dropped by a person is cheap and portable. To find out if such simple devices could be used, one was purchased and some comparison tests were made. The tire was a Michelin MX 145 R10 68S radial ply. The tire and wheel weighed 7.8 kg. The tire had a diameter of 47 cm. The force pulses generated by this tire could be made to satisfy the requirements of the draft standard. The tire machine is, however, far more convenient to use in the laboratory and it was concentrated on during the research. Despite the relatively light weight of the tire and wheel, dropping it manually was quite tiring and produced back strain.

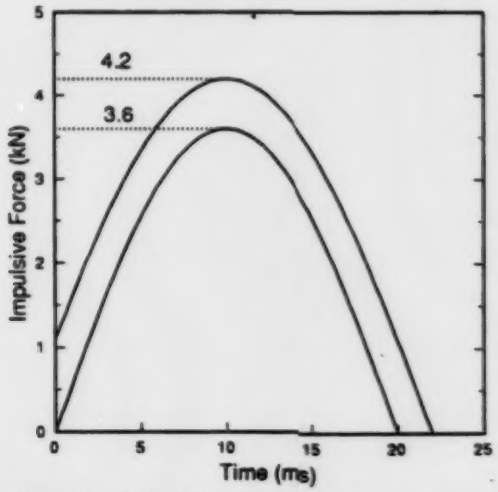


*Figure 17: Limits of force pulse allowed by JIS 1418. The measured force pulse must lie between the two lines.*

## Measurement of Force Pulses

The important property of the tire impactor is the force pulse that it produces when it strikes the floor. Figure 17 shows the limits for force pulse allowed in JIS 1418. The measured force pulse must lie between the two lines. Two

methods for measuring the force pulse were investigated. These are shown schematically in Figure 18.

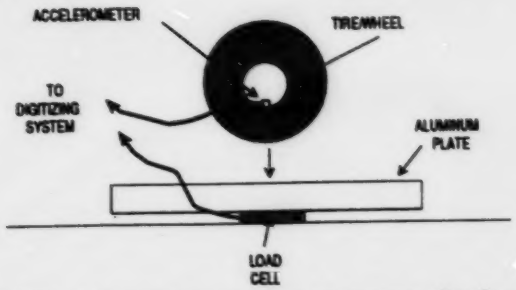


*Figure 18: Apparatus used to measure the force pulse generated by falling tire/wheels.*

The equations governing the impact of the tire on a hard surface are:

$$F_{max} = MV(1+\mu)\pi / (2\,\Delta t)$$

$$\Delta t = \pi(M/k_{eff})^{1/2}$$

$$V^2 = 2\,g\,H$$

where:

$F_{max}$ = maximum impact force, N
$M$ = impactor mass, kg
$V$ = velocity at impact, m/s
$\mu$ = coefficient of restitution
$\Delta t$ = duration time of the impact, s
$k_{eff}$ = spring constant between impactor and the floor
$g$ = acceleration due to gravity, m/s$^2$
$H$ = drop height, m.

For a freely falling wheel, the coefficient of restitution can be calculated from the time between successive impacts on the floor surface. Thus,

$$e = T_2/T_1$$

where $T_1$ is the time between the first and second bounce and $T_2$ is the time between the second and third bounce. Other methods could be used.

All of these factors should be considered by anyone who is designing an impactor for this type of work. Suggested limits for these variables are given in the draft standard, but the important quantities are still the size and shape of the force pulse.

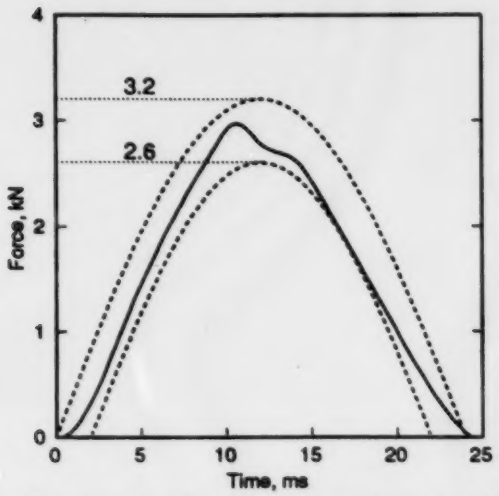


*Figure 19: Measured force for arm length of 64 cm and inflation pressure of 25 psi (solid line). The revised force pulse requirements for use in the proposed ASTM standard are shown as dotted lines.*

**Modifications Made To The Tire Machine**

As delivered, the Tire machine delivered force pulses that conformed to the requirements of the Japanese standard. To reduce the size of the peak force, the machine had to be modified. To do this, the arm supporting the wheel was changed from steel to aluminum and the point of support for the tire along the arm was reduced. Reducing the arm length is equivalent to reducing the drop height for a freely-falling wheel. During operation, the machine tended to move around on the floor. To prevent this, some extra weights were added to the body. A large number of tests were run to collect the data that allowed these changes to be made. Only the important information is summarized in this report.

Figure 19 shows the force pulse for the modified Tire machine measured using the force plate. The accelerometer mounted directly on the wheel rim gave unreliable measurements of the force pulses, and results from it are not shown here.

Figure 19 also shows the current version of the requirements for the force pulse; the peak force is less and the half-period of the pulse is the same. This requirement appears in the draft ASTM standard and was used in all

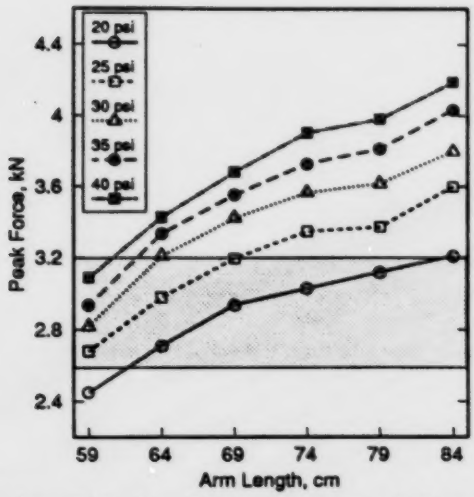


*Figure 20: Relationship between peak force, arm length and inflation pressure for the modified Tire machine. The shaded area shows the allowed range of peak force.*

acoustical tests. The Tire machine setup that gave the force pulse shown in Figure 19 was selected for floor testing.

The measured force pulses do not have the ideal half-sinusoid shape that theory predicts. This is caused by electronic and other instrumental limitations. The peak pulse can be measured precisely with this instrumentation. The precision in the estimate of the half-period is much less because of the gradual start and end of the waveform. One point that will be investigated is whether a specification based only on peak force and the width of the pulse at half its height will give an adequate definition of the impactor.

### Influence of Drop Height and Inflation Pressure on Tire Machine Force Pulses

Using the force plate just described, the influence of the arm length and tire pressure on the force pulse was investigated. Figure 20 shows how peak force varies with arm length and tire pressure. Figure 21 shows how the half-period of the force pulse changes. Several operating points are possible if selection is made only on the basis of peak force and half-period. The point chosen was an arm length of 64 cm and an inflation pressure of 25 psi. As shown in Figure 19, the force pulse generated under these operating conditions lies within the two half-sinusoids proposed for the standard. Many of the other potential operating conditions shown in Figures 20 and 21 give force pulses that do not fit within the half-sinusoids. Results shown later suggest that these requirements are perhaps too restrictive.

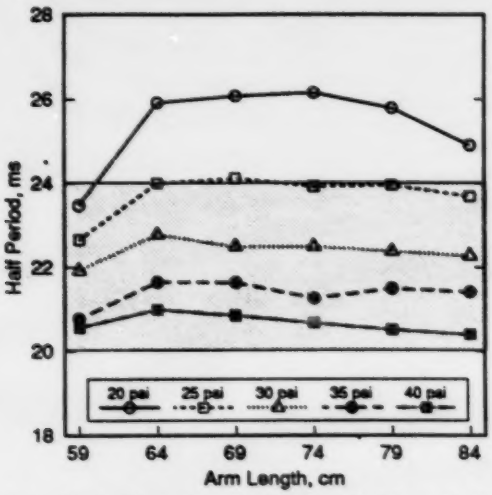


*Figure 21: Relationship between half-period of the force pulse, arm length and inflation pressure for the modified Tire machine. The shaded area shows the allowed range of half-period.*

## Influence Of Some Variables On Impact Peak Sound Pressure Levels Generated By The Tire Machine

### *Effect of Impact Position*

Some members of the ASTM E33 task group were concerned that the impact position of the tire on the floor would have a large effect on the measured peak impact sound pressure levels (SPL). To investigate this, several tests with different impact positions were carried out.

### *Random Positions Versus Fixed Positions*

Random impact positions are convenient when the tire is being dropped by hand — a fairly demanding physical task. When a mechanical device is used to drop the tire, requiring the use of random positions is a great inconvenience for test users. The results below show there is no need for random positions. The differences between positions that are fairly close together are negligible. Because of these findings, the first draft ASTM standard called for five fixed impact positions on a diagonal rather than random positions.

### *Impacts on Joists Versus Impacts Between Joists*

One concern was that there might be a difference in peak impact SPL when the impact is directly on the joist compared to when it is between joists.

Figure 22 compares results for two such positions. The differences are negligible.

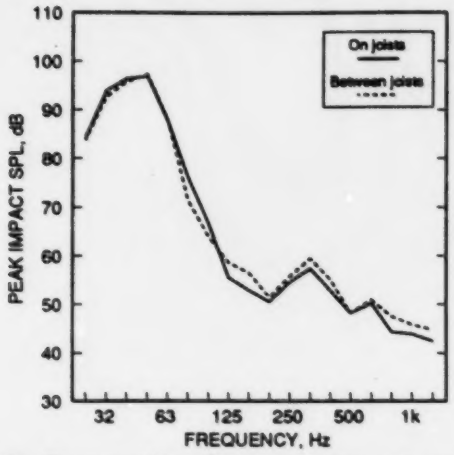


*Figure 22: Comparison between impacts on a joist and mid-way between joists.*

The five fixed impact positions called for in the first draft ASTM standard are shown in Figure 23. Measurements were made at each of the five positions shown in the figure, with the middle position directly on a joist. Another set of positions, displaced from the first one by half of the joist separation, was also used. Figure 24 shows the comparison between the mean values for each case. The differences are negligible.

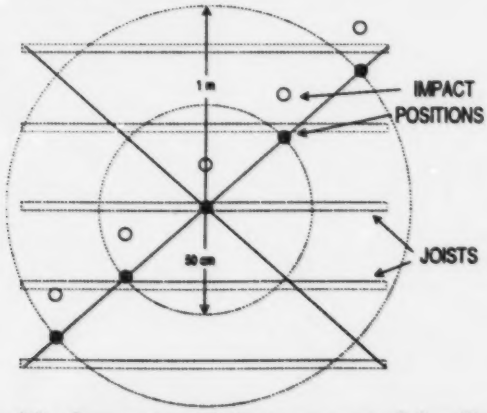


*Figure 23: Impact positions proposed for first ASTM draft test procedure. The open circles mark the alternative set of positions investigated.*

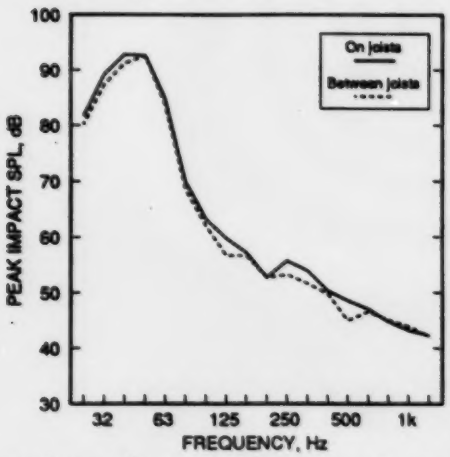


*Figure 24: Mean of five positions on diagonal compared to five positions 0.2 m off the diagonal.*

Figure 25 shows the peak impact SPL at each of the five positions for one of the tests. The point to notice here is that the further the impact position is from the middle of the floor, the lower the peak impact SPL. No new information is obtained by measuring far from the middle of the floor. No matter what kind of averaging is used for these five positions, the mean will be less than the value at the center of the floor.

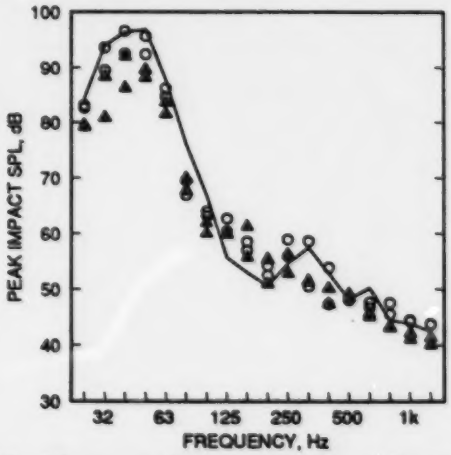


*Figure 25: Mean peak impact SPL at five positions on diagonal of floor. The solid line is for the position at the center of the diagonals. The open circles are for points on the 50 cm circle. The solid triangles are for points on the 1 m circle. (See Fig. 23).*

Because of this, a different array of impact points was chosen for the research. This array is shown in Figure 26. It will provide a conservative rating of the floor being tested. This array will be proposed for any future drafts of the proposed ASTM test. Each position should give about the same

values of peak impact SPL. If the tire is dropped by hand, small changes in the impact position will not be important.

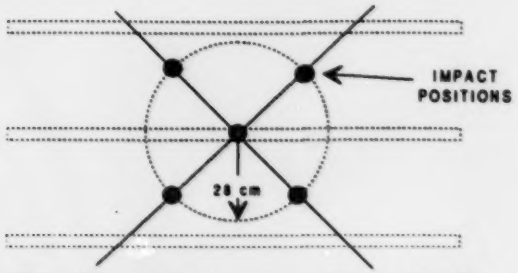


*Figure 26: Array of impact positions finally chosen for the project.*

*Effect of Changes in Inflation Pressure and Drop Height*

The Japanese and the draft ASTM standards allow a range of values for the force pulse generated by the tire impact. With the modified tire machine, several values of inflation pressure and arm length were used, and peak impact SPL was measured. The results are shown in Figure 27. The figure shows that, although many of the operating conditions would not give acceptable force pulses, the differences in peak impact SPL are not large.

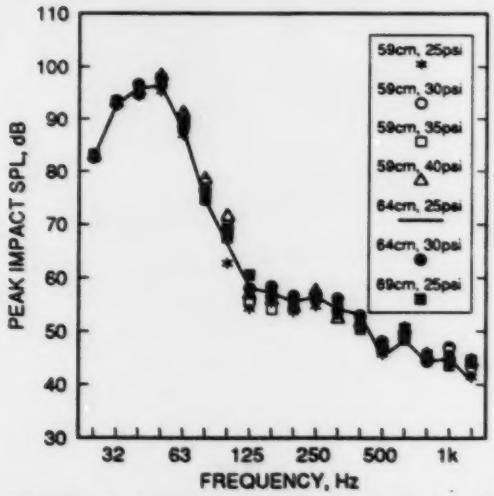


*Figure 27: Peak impact sound pressure levels for several combinations of inflation pressure and arm length. Impacts from the modified tire machine.*

*Effect of the Presence of an Operator on the Floor*

The proposed ASTM standard does not require the use of a Tire machine. Operators are free to drop a wheel/tire by hand. It must be shown then that

the presence of the operator on the floor does not influence the test results. Tests were made with the tire machine and one and then two people standing on the floor during the measurements. The results in Figure 28 show no significant effect. This result is for a lightweight floor where operator weight is comparable to the floor weight. There is no reason to suppose that heavier floors would be more sensitive to the presence of a person on the floor.

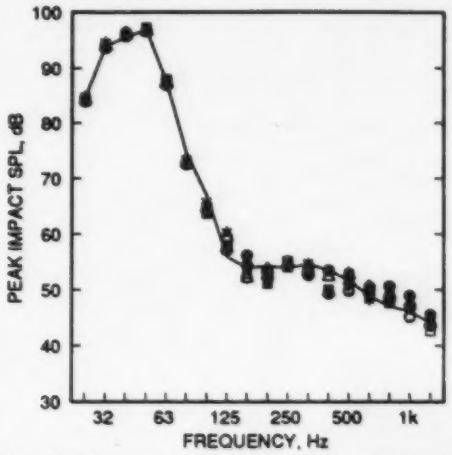


*Figure 28: Peak impact SPLs measured with 0, 1 and 2 people standing on the floor. There were eight tests with people standing on and between joists. Because there are no significant differences, individual curves are not identified.*

### Effect of Microphone Position

The Japanese standard requires measurements at several positions in the room. The approach preferred here is to use a single microphone 1 m below the ceiling. The idea is that this microphone will respond mainly to the sound coming directly from the floor. The room will have less influence on the measurements. This is similar to the use of a microphone placed very close to a musical instrument to reduce the importance of sound from the room. The range of peak impact SPL levels for microphones positioned throughout the small room is shown in Figure 29. In this room, the result for the microphone placed 1 m from the ceiling is close to the maximum level measured in the room, at least at and above 50 Hz. There are some peculiar differences below 50 Hz, but these are not of immediate concern for this project. They would require further investigation to explain why the peak level at 25 Hz close to the floor is lower than that measured in the room. The data shown in the figure do not suggest any need to abandon the use of the 1 m microphone position. In a typical home, with a floor-ceiling distance of about 2.4 m, a point 1 m from the ceiling corresponds roughly to the distance

of the head of a seated person above the floor. This seems like a good choice for the microphone position if a field version of the test is ever produced.

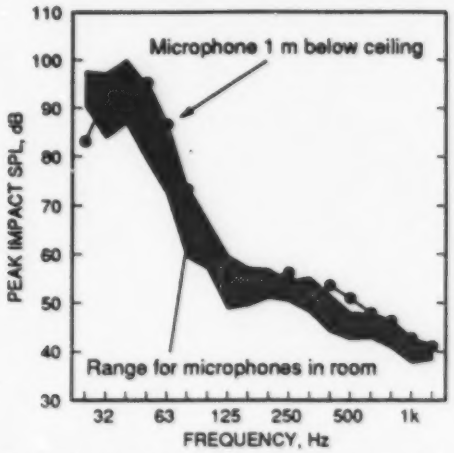


*Figure 29: Comparison of microphone at 1 m position with microphones positioned randomly throughout the volume of the room. Impacts from the tire machine.*

**Repeatability of the Test**

When a test is repeated in a laboratory, one should get about the same answer each time. Figures 30 and 31 show the results of repeated measurements on a single floor for two sets of arm length and tire pressure. The repeatability is good.

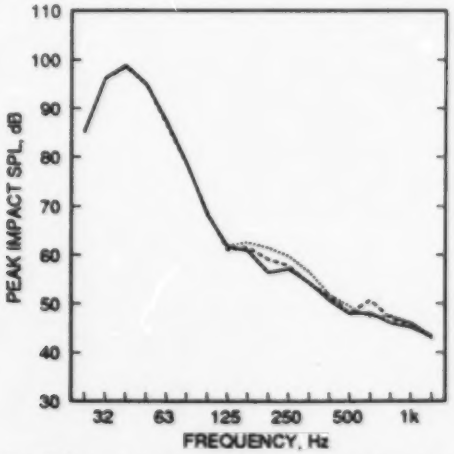


*Figure 30: Three repeated measurements with an arm length of 59 cm and a tire pressure of 35 psi.*

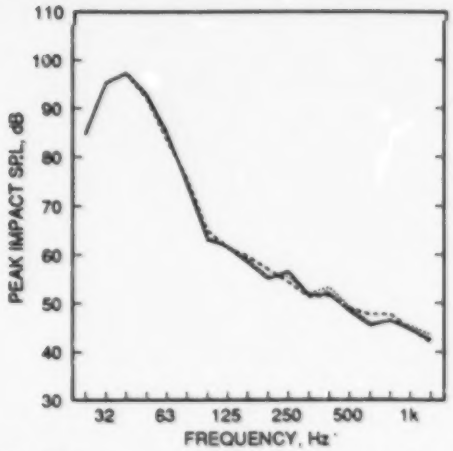


*Figure 31: Three repeated measurements with an arm length of 64 cm and a tire pressure of 25 psi.*

## Outline Of Proposed ASTM Tire Test

- The measured force pulse delivered by the impactor to the floor must fall between the two curves shown earlier in Figure 19. This is the prime requirement for the impactor; other specifications, such as impactor weight and coefficient of restitution, are given to guide users.
- Five impact positions on the floor are to be used: at the intersection of the floor diagonals, and at four points 0.3 m on each side of the intersection point along the diagonals. (See Figure 26.)
- The microphone is to be placed 1 m below the ceiling surface directly beneath the intersection of the floor diagonals. This is the only microphone position used.
- Peak levels shall be measured for at least 10 impacts at each position. The time between impacts should be long enough so the decaying sound level from the previous impact is at least 15 dB below the current peak level in all bands.
- Measurements are to be made in the one-third-octave bands with center frequencies from 50 to 1250 Hz.
- The time constant for measurement is to be 35 ms.

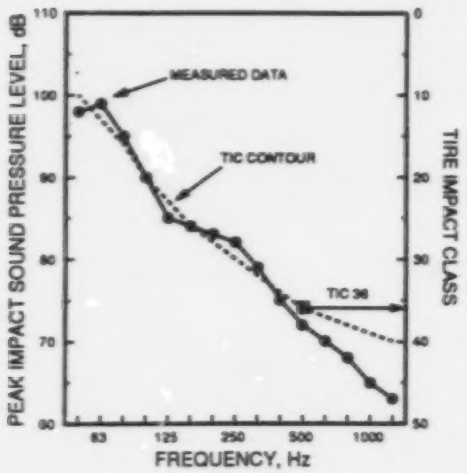


*Figure 32: An example of test results and the fitted TIC contour. The TIC is 36.*

**Single Number Ratings - TIC and A-weighted Level**

For the research project, the single number rating proposed was the tire impact class, TIC. It is a modified version of the Japanese single number rating. Like IIC, if the floor improves, the TIC rating gets larger. Figure 32 shows an example of measured data and the fitted TIC contour. Once the fitting procedure is complete, the value of TIC is read on the right hand axis at the level of the 500 Hz point on the contour.

TIC is derived in a similar way to impact insulation class, IIC. To determine the tire impact class, TIC, the measured peak impact sound pressure levels are compared with a reference contour. The contour is illustrated in Fig. 32 and tabulated in Table B1 for a TIC value of 50. Other TIC contours can be calculated by adding or subtracting a integer constants to all the one-third octave band values in the table. The test data are compared to TIC contours until no measured value exceeds the contour by more than 2 dB. In theory, all measured bands may lie 2 dB above the TIC contour. The TIC value is found by subtracting the contour value at 500 Hz from 110.

| Table B1: Contour values for TIC 50. | | | |
|---|---|---|---|
| Freq (Hz) | Contour (dB) | Freq (Hz) | Contour (dB) |
| 50 | 86 | 315 | 64 |
| 63 | 83 | 400 | 62 |
| 80 | 80 | 500 | 60 |
| 100 | 76 | 630 | 59 |
| 125 | 73 | 800 | 58 |
| 160 | 70 | 1k | 57 |
| 200 | 68 | 1.25k | 56 |
| 250 | 66 | | |

# Appendix C
# Descriptions of Floor Specimens

*Basic Floors tested*

Two types of wood joist floors, three types of wood truss floors and one solid concrete floor were tested. As well as testing the basic floor with the top surface unfinished (hard), five different floor coverings were placed on top of the floors. These were a carpet, a carpet and underpad and three types of floating floor. These are described in the next section.

The construction of the basic floors is given in Table C1. The descriptions of the floating floors are given in Table C2. The physical characteristics of the materials used are given in Table C3.

The floor Joist1 is essentially the same construction that was tested in a previous contract for CMHC [9]. Sound transmission class (STC) and impact insulation class (IIC) measurements were repeated and additional surface layers were re-installed for this work. There are differences between this set of results and those in the previous report. These can be attributed to unknown differences in construction.

Note that a description is included for Truss1-w. This is floor Truss1 with the resilient metal channels installed incorrectly; the flange that the drywall is normally attached to was screwed directly to the joists. The channels were therefore not as free to vibrate but the data show that the sound insulation was not significantly affected.

Table C1: Basic floor constructions tested

| Floor Designation | Construction |
|---|---|
| Joist1 | 16 mm tongue and groove plywood<br>240 x 38 mm wood joists<br>three layers of 90 mm thick glass fiber batts<br>13 mm resilient metal channels 60 cm oc<br>two layers of 16 mm drywall |
| Joist2 | 16 mm tongue and groove plywood<br>240 x 38 mm wood joists<br>one layer of 90 mm thick glass fiber batts<br>13 mm resilient metal channels 60 cm oc<br>one layer of 16 mm drywall |

| | |
|---|---|
| Truss1 | 16 mm tongue and groove plywood<br>240 x 38 mm wood trusses<br>two layers of 90 mm thick glass fiber batts<br>13 mm resilient metal channels 60 cm oc<br>one layer of 16 mm drywall |
| Truss1-w | Truss1 with resilient metal channels installed incorrectly |
| Truss2 | 16 mm tongue and groove plywood<br>300 x 38 mm wood trusses<br>three layers of 75 mm thick glass fiber batts<br>13 mm resilient metal channels 60 cm oc<br>one layer of 16 mm drywall |
| Truss3 | 16 mm tongue and groove plywood<br>400 x 38 mm wood trusses<br>280 mm thickness of glass fiber batts<br>13 mm resilient metal channels 60 cm oc<br>one layer of 16 mm drywall |
| Conc1 | 150 mm concrete slab |
| Djoist1 | 16 mm tongue and groove plywood<br>19 mm wood fibre board<br>240 x 38 mm wood joists on 290 mm headers<br>200 mm thickness of glass fiber batts<br>13 mm 13 mm Ethafoam<br>140 x 38 mm wood joists<br>150 mm thickness of glass fiber batts<br>13 mm resilient metal channels 60 cm oc<br>one layer of 16 mm drywall |
| Djoist2 | 16 mm tongue and groove plywood<br>19 mm wood fibre board<br>240 x 38 mm wood joists on 290 mm headers<br>200 mm thickness of glass fiber batts<br>13 mm 13 mm Ethafoam<br>140 x 38 mm wood joists<br>150 mm thickness of glass fiber batts<br>one layer of 16 mm drywall |
| Djoist3 | 16 mm tongue and groove plywood<br>240 x 38 mm wood joists on 290 mm headers<br>200 mm thickness of glass fiber batts<br>13 mm 13 mm Ethafoam<br>140 x 38 mm wood joists<br>150 mm thickness of glass fiber batts<br>one layer of 16 mm drywall |

| Table C2: Floating floor descriptions | |
|---|---|
| Float1 | 40 mm thick layer of concrete resting on 25 mm AF530 glass fibre board |
| Float2 | 40 mm thick layer of concrete resting on 21 mm rubber pads with AF331 glass batts in the cavity. |
| Float3 | 16 mm thick layer of plywood resting on 40 x 90 mm wood strapping laid on 25 mm AF570 glass fibre board |

Table C3: Physical Information on materials used

| Material | Density kg/m$^2$ | Weight kg |
|---|---|---|
| *Sound absorbing materials* | | |
| 270 mm glass fibre batt insulation (3 layers of 90 mm), density 13.5 kg/m$^3$ | 3.7 | 21 |
| 180 mm glass fibre batt insulation (2 layers of 90 mm), density 13.5 kg/m$^3$ | 2.4 | 14 |
| *Structural Materials for basic floors* | | |
| 150 mm reinforced concrete slab, 2380 kg/m$^3$ | 357 | 2066 |
| 16 mm tongue and groove plywood, screws applied 400 mm oc at the edge and in the field | 7.5 | 43.3 |
| 13 mm resilient metal channels, 600 mm oc, 0.24 kg/m. 5 used | | 2.9 |
| 16 mm drywall | 11.1 | 63.9 |
| 235 mm wood joists, 400 mm oc. Joist length 2.35 m. 4.4 kg/m, 10.3 kg/joist. 7 joists used | | 72.1 |
| 235 mm wood trusses, 400 mm oc. 7 trusses used. 10.9 kg/truss. Formed from 4x9 cm wood studs and solid web of 11 mm waferboard. Truss length 2.36 m. 4.6 kg/m | | 76.3 |
| 300 mm wood trusses, 400 mm oc. 7 trusses used. 12.1 kg/truss. Formed from 4x9 cm wood studs and solid web of 11 mm waferboard. Truss length 2.36 m. 5.1 kg/m | | 84.7 |

| | | |
|---|---|---|
| 400 mm wood trusses, 400 mm oc, 12.25 kg/truss, 5.21 kg/m. 7 trusses used. Truss length 2.35 m. Formed from 4x9 cm wood studs and 11 mm plywood web | | 85.8 |

*Floor coverings*

| | | |
|---|---|---|
| 10 mm thick, grey loop pile carpet. The pile was 9 mm and the jute backing was 1 mm thick | 2.9 | 16.4 |
| 10 mm thick brown foam-backed carpet. The pile was 5 mm thick, the jute backing was 1 mm thick and the foam layer was 4 mm thick | 2.3 | 13.3 |
| 6 mm thick felt carpet underpad (coated one side) | 1.7 | 9.8 |
| 9 mm thick blue foam carpet underpad | 0.4 | 2.3 |

*Materials for Floating floors*

| | | |
|---|---|---|
| 16 mm laminated plywood, two layers of 8 mm plywood laminated together | 18 | 103.7 |
| 40 mm reinforced lightweight concrete slab, 1915 kg/m$^3$ | 76.6 | 441.2 |
| 19 mm Wonderboard, two 6 mm layers laminated with 6 mm mortar (cement slurry) | 23.2 | 133.6 |
| 25 mm AF530 glass fiber board, 50 kg/m$^3$ | 1.2 | 7.2 |
| 25 mm AF570 glass fiber board, 113.7 kg/m$^3$ | 2.8 | 16.4 |
| 19 mm wood fibreboard | 5 | 30 |
| 11 mm wood fibreboard | 2.9 | 16.8 |

# Appendix D

## Tables of Results

*Table D1: ASTM E90 Airborne Sound Transmission Data*

| | | STC | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Joist1 = PLY16_WJ240_GFB90_GFB90_GFB90_RC13_G16_G16** | | | | | | | | | | | | | | | | | | | | | | | |
| TL-90-135 | Bare | 55 | 27 | 27 | 36 | 34 | 40 | 42 | 46 | 49 | 52 | 54 | 54 | 56 | 58 | 59 | 59 | 58 | 55 | 58 | 61 | 65 | 70 |
| TL-90-136 | Grey Carpet | 58 | 26 | 30 | 37 | 39 | 42 | 44 | 48 | 51 | 54 | 55 | 55 | 58 | 59 | 60 | 61 | 61 | 59 | 62 | 66 | 70 | 75 |
| TL-90-137 | 9mm foam underpad and grey carpet | 58 | 27 | 31 | 37 | 38 | 42 | 43 | 47 | 50 | 52 | 55 | 56 | 59 | 62 | 64 | 66 | 67 | 65 | 65 | 67 | 71 | 75 |
| TL-90-138 | 6mm felt and grey carpet | 59 | 27 | 32 | 38 | 39 | 43 | 44 | 48 | 51 | 53 | 55 | 56 | 59 | 61 | 65 | 66 | 66 | 64 | 65 | 67 | 71 | 75 |
| TL-90-139 | Brown Foam-backed carpet | 58 | 25 | 29 | 36 | 37 | 41 | 43 | 47 | 51 | 54 | 55 | 57 | 59 | 61 | 63 | 64 | 64 | 63 | 64 | 67 | 71 | 75 |
| TL-90-140 | 16 mm plywood raft on 6 mm felt | 61 | 27 | 37 | 41 | 41 | 45 | 44 | 48 | 51 | 56 | 58 | 59 | 62 | 64 | 67 | 68 | 68 | 65 | 65 | 67 | 71 | 75 |
| TL-90-141 | 16 mm plywood raft on 3 mm neoprene | 60 | 25 | 35 | 40 | 42 | 45 | 46 | 49 | 52 | 54 | 55 | 57 | 60 | 62 | 65 | 67 | 66 | 64 | 65 | 67 | 71 | 75 |
| TL-90-142 | 18 mm Wonderboard screwed to plywood | 62 | 35 | 43 | 46 | 46 | 48 | 48 | 51 | 54 | 56 | 59 | 60 | 62 | 64 | 65 | 65 | 66 | 64 | 65 | 67 | 71 | 75 |
| TL-90-143 | Grey carpet on 18 mm Wonderboard screwed to plywood | 62 | 35 | 43 | 46 | 47 | 48 | 48 | 51 | 54 | 57 | 58 | 60 | 62 | 64 | 65 | 66 | 66 | 64 | 65 | 67 | 71 | 75 |
| TL-90-144 | Additional 16 mm plywood layer screwed to floor | 59 | 26 | 34 | 39 | 39 | 44 | 46 | 50 | 53 | 55 | 56 | 57 | 60 | 61 | 63 | 64 | 62 | 58 | 60 | 63 | 67 | 71 |
| TL-90-145 | 16 mm plywood raft glued to 11 mm fibreboard | 62 | 28 | 36 | 41 | 43 | 47 | 47 | 51 | 54 | 57 | 59 | 60 | 62 | 64 | 67 | 68 | 68 | 65 | 65 | 67 | 71 | 75 |

**Joist2 = PLY16_WJ240_GFB90_RC13_G16**

In all following tests the carpet used was the Grey carpet and the underpad was the 9 mm thick blue foam underpad

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-001 | 40 mm concrete on building paper | 59 | 33 | 41 | 47 | 48 | 46 | 45 | 48 | 49 | 52 | 53 | 55 | 59 | 62 | 65 | 67 | 67 | 64 | 65 | 67 | 71 | 75 |
| TL-91-002 | Carpet on 40 mm concrete on building paper | 59 | 35 | 42 | 46 | 48 | 45 | 45 | 47 | 49 | 52 | 52 | 54 | 58 | 62 | 64 | 66 | 66 | 63 | 65 | 67 | 71 | 74 |
| TL-91-003 | Carpet and underpad on 40 mm concrete on building paper | 58 | 34 | 41 | 46 | 47 | 45 | 44 | 47 | 49 | 51 | 53 | 55 | 59 | 62 | 65 | 67 | 67 | 63 | 65 | 67 | 71 | 74 |
| TL-91-004 | Bare | 49 | 19 | 23 | 27 | 29 | 32 | 34 | 37 | 41 | 46 | 48 | 48 | 52 | 55 | 56 | 56 | 53 | 50 | 53 | 57 | 61 | 66 |
| TL-91-005 | 40 mm concrete on hard neoprene pads | 58 | 37 | 42 | 46 | 48 | 46 | 45 | 47 | 48 | 51 | 52 | 54 | 59 | 63 | 66 | 67 | 66 | 62 | 64 | 66 | 71 | 74 |
| TL-91-006 | 40 mm concrete on soft cork pads | 59 | 37 | 42 | 45 | 47 | 44 | 45 | 47 | 49 | 52 | 54 | 55 | 60 | 63 | 66 | 68 | 68 | 64 | 66 | 68 | 72 | 76 |
| TL-91-007 | 40 mm concrete on hard cork pads | 59 | 37 | 43 | 46 | 48 | 46 | 46 | 47 | 49 | 52 | 53 | 54 | 59 | 63 | 66 | 68 | 67 | 63 | 65 | 67 | 72 | 76 |
| TL-91-008 | 40 mm concrete on hard neoprene pads on joists | 59 | 37 | 43 | 46 | 49 | 45 | 44 | 46 | 49 | 52 | 53 | 55 | 60 | 63 | 66 | 68 | 68 | 65 | 66 | 68 | 72 | 76 |
| TL-91-009 | 40 mm concrete on hard neoprene pads between joists | 59 | 38 | 43 | 46 | 47 | 45 | 45 | 46 | 49 | 52 | 53 | 55 | 59 | 63 | 66 | 68 | 67 | 64 | 65 | 67 | 71 | 75 |
| TL-91-010 | 40 mm concrete on soft neoprene pads | 59 | 38 | 43 | 45 | 47 | 45 | 45 | 46 | 48 | 52 | 53 | 55 | 59 | 63 | 66 | 68 | 67 | 64 | 65 | 67 | 72 | 74 |
| TL-91-011 | 40 mm concrete on very soft neoprene pads | 58 | 37 | 43 | 46 | 47 | 45 | 45 | 46 | 48 | 52 | 53 | 54 | 59 | 63 | 66 | 67 | 67 | 63 | 64 | 66 | 71 | 75 |
| TL-91-012 | Float2 | 59 | 40 | 43 | 46 | 47 | 44 | 45 | 47 | 49 | 53 | 56 | 57 | 60 | 63 | 66 | 67 | 67 | 64 | 65 | 67 | 72 | 75 |
| TL-91-013 | Float1 | 60 | 41 | 44 | 46 | 45 | 46 | 45 | 47 | 49 | 53 | 56 | 57 | 60 | 63 | 66 | 67 | 67 | 64 | 65 | 67 | 72 | 75 |
| TL-91-014 | Float3 | 57 | 25 | 29 | 33 | 37 | 39 | 42 | 45 | 48 | 52 | 54 | 57 | 60 | 63 | 65 | 67 | 67 | 65 | 66 | 68 | 72 | 75 |
| TL-91-015 | Carpet and underpad on Float3 | 57 | 26 | 30 | 34 | 37 | 38 | 42 | 45 | 48 | 53 | 55 | 58 | 60 | 63 | 66 | 68 | 68 | 66 | 66 | 68 | 72 | 76 |

**Truss1-w = PLY16_WT235_GFB90_GFB90_RC13_G16**

**Resilient channels installed wrongly**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-018 | Bare | 50 | 22 | 22 | 27 | 31 | 33 | 33 | 37 | 42 | 46 | 49 | 51 | 53 | 56 | 57 | 56 | 53 | 52 | 56 | 59 | 63 | 68 |
| TL-91-024 | Carpet | 51 | 23 | 21 | 27 | 33 | 34 | 34 | 39 | 42 | 46 | 49 | 51 | 52 | 54 | 57 | 57 | 54 | 55 | 60 | 65 | 71 | 76 |
| TL-91-025 | Carpet | 52 | 25 | 23 | 27 | 32 | 36 | 36 | 41 | 43 | 48 | 51 | 53 | 56 | 58 | 59 | 58 | 55 | 56 | 61 | 66 | 71 | 76 |
| TL-91-026 | Bare | 51 | 24 | 22 | 26 | 30 | 33 | 34 | 38 | 42 | 47 | 50 | 53 | 55 | 58 | 58 | 56 | 53 | 52 | 56 | 60 | 63 | 69 |
| TL-91-027 | Carpet and Underpad | 52 | 25 | 23 | 27 | 31 | 35 | 35 | 39 | 42 | 47 | 50 | 54 | 57 | 61 | 64 | 65 | 65 | 67 | 68 | 71 | 74 | 78 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-028 | Float1 | 60 | 39 | 37 | 40 | 42 | 45 | 47 | 48 | 49 | 53 | 55 | 58 | 60 | 64 | 67 | 69 | 69 | 69 | 69 | 71 | 74 | 78 |
| TL-91-032 | Float2 | 59 | 39 | 38 | 42 | 41 | 42 | 46 | 47 | 49 | 52 | 55 | 57 | 60 | 63 | 67 | 69 | 68 | 68 | 68 | 71 | 76 | 78 |
| TL-91-043 | Float3 | 58 | 24 | 25 | 30 | 34 | 42 | 45 | 46 | 48 | 52 | 56 | 60 | 63 | 68 | 73 | 74 | 72 | 72 | 75 | 78 | 81 | 80 |
| TL-91-048 | Float3 | 57 | 24 | 27 | 28 | 33 | 41 | 46 | 48 | 49 | 52 | 56 | 59 | 62 | 67 | 72 | 74 | 76 | 79 | 79 | 83 | 84 | 84 |

**Truss1-13 = PLY16_WT235_GFB90_GFB90_RC13_G13**

**Truss1 with 13 mm instead of 16 mm drywall**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-060 | Bare | 51 | 19 | 21 | 24 | 26 | 33 | 34 | 39 | 42 | 47 | 50 | 54 | 57 | 61 | 63 | 62 | 62 | 61 | 59 | 62 | 65 | 71 |
| TL-91-076 | Bare | 50 | 20 | 23 | 25 | 26 | 33 | 33 | 40 | 44 | 49 | 50 | 54 | 56 | 60 | 62 | 62 | 62 | 59 | 59 | 62 | 65 | 70 |

**Truss1 = PLY16_WT240_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-080 | Bare | 48 | 25 | 24 | 22 | 23 | 31 | 34 | 39 | 43 | 47 | 49 | 53 | 56 | 59 | 60 | 58 | 56 | 57 | 61 | 64 | 67 | 72 |
| TL-91-088 | Carpet | 50 | 25 | 24 | 24 | 25 | 32 | 35 | 39 | 44 | 48 | 49 | 52 | 55 | 58 | 60 | 59 | 58 | 60 | 66 | 72 | 77 | 82 |
| TL-91-089 | Carpet and underpad | 50 | 25 | 25 | 25 | 26 | 31 | 34 | 38 | 43 | 47 | 50 | 54 | 58 | 63 | 66 | 67 | 68 | 70 | 74 | 78 | 81 | 83 |
| TL-91-112 | Float1 | 60 | 38 | 37 | 40 | 41 | 43 | 48 | 49 | 50 | 53 | 56 | 60 | 64 | 68 | 73 | 74 | 74 | 74 | 76 | 79 | 82 | 84 |
| TL-91-113 | Float2 | 60 | 36 | 37 | 39 | 41 | 43 | 47 | 49 | 50 | 54 | 56 | 60 | 64 | 69 | 73 | 74 | 75 | 74 | 76 | 78 | 82 | 84 |
| TL-91-114 | Float3 | 55 | 24 | 26 | 26 | 30 | 40 | 45 | 48 | 51 | 54 | 57 | 61 | 65 | 69 | 73 | 75 | 75 | 75 | 77 | 80 | 83 | 83 |

**Truss2 = PLY16_WT300_GFB75_GFB75_GFB75_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-119 | Bare | 55 | 21 | 25 | 31 | 32 | 40 | 42 | 43 | 46 | 50 | 54 | 56 | 59 | 62 | 64 | 62 | 60 | 59 | 62 | 65 | 69 | 75 |
| TL-91-120 | Carpet | 57 | 23 | 28 | 33 | 33 | 42 | 43 | 45 | 47 | 51 | 54 | 56 | 59 | 62 | 64 | 64 | 63 | 63 | 67 | 72 | 78 | 82 |
| TL-91-121 | Carpet and underpad | 56 | 22 | 27 | 32 | 33 | 41 | 42 | 44 | 47 | 50 | 54 | 57 | 61 | 64 | 68 | 70 | 71 | 72 | 75 | 78 | 82 | 83 |
| TL-91-122 | Float1 | 62 | 40 | 44 | 41 | 44 | 50 | 49 | 48 | 51 | 55 | 59 | 62 | 66 | 69 | 73 | 75 | 74 | 73 | 75 | 78 | 82 | 83 |
| TL-91-131 | Float2 | 62 | 43 | 46 | 44 | 46 | 48 | 48 | 48 | 50 | 54 | 58 | 62 | 65 | 69 | 72 | 74 | 75 | 74 | 76 | 78 | 82 | 83 |
| TL-91-133 | Float3 | 60 | 26 | 31 | 32 | 36 | 45 | 48 | 48 | 51 | 55 | 58 | 62 | 65 | 69 | 73 | 75 | 75 | 76 | 77 | 80 | 82 | 83 |

**Conc1 = 150 mm concrete slab**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-138 | Bare | 52 | 45 | 45 | 42 | 43 | 39 | 37 | 43 | 39 | 48 | 46 | 51 | 55 | 55 | 59 | 61 | 64 | 67 | 70 | 72 | 74 | 76 |
| TL-91-139 | Carpet | 52 | 46 | 46 | 42 | 44 | 39 | 38 | 42 | 40 | 49 | 46 | 51 | 53 | 54 | 56 | 59 | 64 | 69 | 73 | 78 | 81 | 83 |
| TL-91-140 | Carpet and underpad | 51 | 45 | 47 | 41 | 42 | 39 | 37 | 42 | 39 | 47 | 46 | 51 | 56 | 58 | 64 | 68 | 72 | 76 | 79 | 81 | 82 | 82 |
| TL-91-145 | CON40_GFR25_CON150 | 62 | 37 | 49 | 48 | 47 | 43 | 44 | 50 | 53 | 56 | 57 | 60 | 64 | 66 | 69 | 70 | 73 | 76 | 79 | 81 | 82 | 83 |
| TL-91-146 | Float1 | 62 | 36 | 45 | 48 | 47 | 43 | 45 | 50 | 53 | 57 | 57 | 59 | 64 | 66 | 69 | 70 | 73 | 76 | 79 | 81 | 82 | 83 |
| TL-91-147 | 40 mm concrete slab on 18 mm soft neoprene pads | 60 | 32 | 40 | 43 | 45 | 42 | 43 | 49 | 52 | 55 | 56 | 59 | 63 | 66 | 69 | 70 | 73 | 77 | 78 | 81 | 82 | 83 |
| TL-91-148 | Float2 with no AF331 | 61 | 39 | 38 | 40 | 41 | 41 | 43 | 50 | 53 | 56 | 57 | 60 | 64 | 67 | 70 | 72 | 74 | 77 | 79 | 81 | 82 | 83 |
| TL-91-149 | Float2 | 62 | 38 | 42 | 43 | 45 | 43 | 44 | 50 | 53 | 57 | 58 | 61 | 65 | 67 | 70 | 72 | 74 | 78 | 79 | 81 | 82 | 83 |
| TL-91-150 | Float3 | 61 | 39 | 37 | 40 | 43 | 44 | 46 | 51 | 52 | 56 | 57 | 60 | 64 | 67 | 70 | 72 | 75 | 78 | 79 | 81 | 83 | 83 |
| TL-91-153 | Float3 but with 80 mm deep furring | 62 | 36 | 44 | 43 | 44 | 44 | 45 | 51 | 53 | 56 | 57 | 61 | 64 | 67 | 70 | 73 | 75 | 78 | 79 | 81 | 83 | 84 |

**Truss3-s = PLY16_WT400_GFB90_GFB90_GFB90_RC13_G16**
**not quite enough glass fibre**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-155 | Bare | 53 | 25 | 29 | 35 | 38 | 39 | 35 | 38 | 42 | 48 | 50 | 52 | 56 | 59 | 60 | 59 | 56 | 54 | 57 | 59 | 64 | 69 |
| TL-91-156 | Carpet | 55 | 27 | 32 | 36 | 39 | 40 | 40 | 42 | 46 | 49 | 51 | 54 | 57 | 59 | 60 | 60 | 59 | 58 | 62 | 67 | 74 | 79 |
| TL-91-157 | Carpet and underpad | 55 | 27 | 31 | 35 | 38 | 40 | 40 | 41 | 44 | 48 | 51 | 54 | 59 | 61 | 65 | 66 | 67 | 66 | 72 | 76 | 80 | 81 |

**Truss3 = PLY16_WT400_GFB10_GFB90_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-158 | Bare | 54 | 26 | 30 | 34 | 38 | 38 | 38 | 40 | 45 | 50 | 52 | 55 | 59 | 62 | 63 | 62 | 59 | 56 | 59 | 61 | 66 | 71 |
| TL-91-159 | Carpet | 56 | 28 | 31 | 35 | 39 | 40 | 41 | 43 | 47 | 51 | 53 | 56 | 60 | 61 | 63 | 63 | 61 | 60 | 64 | 69 | 76 | 80 |
| TL-91-160 | Carpet and underpad | 56 | 28 | 31 | 35 | 38 | 39 | 40 | 42 | 46 | 50 | 52 | 56 | 60 | 64 | 67 | 69 | 70 | 70 | 75 | 79 | 81 | 81 |
| TL-91-163 | Float1 | 60 | 39 | 41 | 35 | 40 | 46 | 49 | 48 | 49 | 54 | 56 | 59 | 62 | 67 | 71 | 73 | 73 | 72 | 74 | 77 | 79 | 80 |
| TL-91-164 | Float2 | 60 | 41 | 43 | 39 | 43 | 45 | 47 | 48 | 49 | 53 | 56 | 60 | 62 | 67 | 70 | 72 | 72 | 71 | 73 | 76 | 78 | 80 |
| TL-91-165 | Float3 | 57 | 27 | 29 | 27 | 33 | 43 | 48 | 48 | 50 | 54 | 56 | 60 | 63 | 67 | 71 | 73 | 73 | 72 | 75 | 77 | 79 | 80 |

**Djoist1 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_RC13_G16**

**With 19 mm wood fiberboard and Resilient channels**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-166 | Bare | 59 | 36 | 42 | 41 | 41 | 42 | 44 | 47 | 49 | 54 | 56 | 59 | 64 | 68 | 71 | 72 | 71 | 71 | 75 | 79 | 81 | 79 |
| TL-91-167 | Carpet | 59 | 37 | 42 | 41 | 41 | 42 | 44 | 47 | 50 | 54 | 56 | 60 | 64 | 68 | 71 | 72 | 71 | 71 | 75 | 78 | 80 | 79 |
| TL-91-168 | Carpet and underpad | 59 | 36 | 42 | 41 | 40 | 42 | 44 | 46 | 50 | 54 | 56 | 59 | 64 | 68 | 71 | 72 | 71 | 71 | 75 | 78 | 80 | 80 |
| TL-91-169 | 40 mm concrete | 61 | 45 | 50 | 46 | 47 | 45 | 47 | 49 | 50 | 54 | 56 | 60 | 64 | 67 | 71 | 72 | 70 | 69 | 73 | 76 | 79 | 78 |

**Djoist2 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

**Resilient channels removed from Djoist1**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-170 | Joist4 + 40 mm concrete | 61 | 35 | 43 | 44 | 47 | 45 | 47 | 49 | 51 | 54 | 57 | 60 | 64 | 67 | 71 | 69 | 67 | 68 | 73 | 77 | 79 | 77 |
| TL-91-171 | Bare | 57 | 29 | 35 | 36 | 39 | 39 | 39 | 44 | 47 | 51 | 55 | 59 | 64 | 67 | 70 | 71 | 69 | 70 | 75 | 79 | 80 | 81 |

**Djoist3 = PLY16_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

**19 mm Wood fiberboard removed from Djoist2**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-91-172 | Bare | 55 | 26 | 33 | 33 | 38 | 38 | 38 | 39 | 44 | 50 | 54 | 56 | 62 | 65 | 69 | 68 | 65 | 66 | 70 | 74 | 76 | 80 |

## *Table D2: ASTM E492 Impact Sound Transmission Data*

| TestID | Floor Topping or covering | IIC | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Joist1=PLY16_WJ240_GFB90_GFB90_GFB90_RC13_G16_G16** | | | | | | | | | | | | | | | | | | | | | | | | |
| II-90-028 | Bare | 51 | 73 | 72 | 63 | 62 | 59 | 63 | 62 | 62 | 61 | 59 | 59 | 57 | 55 | 50 | 48 | 48 | 49 | 43 | 38 | 33 | 29 | |
| II-90-029 | Grey Carpet | 65 | 69 | 66 | 55 | 51 | 44 | 41 | 37 | 33 | 27 | 20 | 18 | 15 | 13 | 11 | 10 | 11 | 11 | 7 | 4 | 3 | 1 | |
| II-90-031 | 9mm foam underpad and grey carpet | 80 | 56 | 49 | 40 | 36 | 26 | 24 | 20 | 20 | 16 | 11 | 7 | 3 | 1 | 0 | 1 | 2 | 2 | 1 | 1 | 2 | 3 | |
| II-90-032 | 6mm felt and grey carpet | 69 | 66 | 60 | 50 | 45 | 37 | 33 | 28 | 28 | 22 | 17 | 13 | 9 | 5 | 2 | 3 | 4 | 3 | 2 | 2 | 2 | 3 | |
| II-90-033 | Brown Foam-backed carpet | 65 | 69 | 66 | 54 | 50 | 44 | 42 | 36 | 32 | 26 | 17 | 13 | 8 | 4 | 3 | 3 | 5 | 5 | 3 | 3 | 3 | 5 | |
| II-90-034 | 16 mm plywood raft on 6 mm felt | 57 | 72 | 63 | 60 | 60 | 56 | 60 | 58 | 58 | 57 | 52 | 52 | 49 | 45 | 40 | 35 | 34 | 33 | 28 | 25 | 23 | 22 | |
| II-90-035 | 16 mm plywood raft on 3 mm neoprene | 56 | 73 | 64 | 60 | 59 | 56 | 59 | 59 | 59 | 59 | 54 | 53 | 50 | 47 | 43 | 39 | 38 | 38 | 32 | 27 | 25 | 22 | |
| II-90-036 | 18 mm Wonderboard screwed to plywood | 53 | 61 | 55 | 58 | 56 | 54 | 56 | 55 | 55 | 56 | 55 | 55 | 54 | 51 | 50 | 48 | 48 | 49 | 44 | 39 | 33 | 27 | |
| II-90-037 | Grey carpet on 18 mm Wonderboard screwed to plywood | 68 | 60 | 54 | 51 | 49 | 43 | 41 | 38 | 32 | 27 | 21 | 15 | 11 | 8 | 7 | 8 | 8 | 9 | 8 | 8 | 9 | 10 | |
| II-90-038 | Additional 16 mm plywood layer screwed to floor | 54 | 74 | 67 | 64 | 63 | 60 | 63 | 62 | 60 | 58 | 55 | 54 | 51 | 48 | 43 | 40 | 40 | 41 | 37 | 33 | 29 | 25 | |
| II-90-039 | 16 mm plywood raft glued to 11 mm fibreboard | 58 | 72 | 62 | 61 | 59 | 57 | 57 | 55 | 54 | 51 | 48 | 45 | 43 | 41 | 37 | 33 | 33 | 33 | 28 | 23 | 20 | 15 | |
| **Joist2 = PLY16_WJ240_GFB90_RC13_G16** | | | | | | | | | | | | | | | | | | | | | | | | |
| In all following tests the carpet used was the Grey carpet and the underpad was the 9 mm thick blue foam underpad | | | | | | | | | | | | | | | | | | | | | | | | |
| II-91-001 | 40 mm concrete on building paper | 40 | 60 | 53 | 52 | 52 | 55 | 54 | 54 | 57 | 57 | 58 | 55 | 55 | 55 | 54 | 55 | 59 | 63 | 60 | 55 | 50 | 44 | |
| II-91-002 | Carpet on 40 mm concrete on building paper | 73 | 60 | 51 | 47 | 46 | 46 | 40 | 37 | 37 | 31 | 25 | 18 | 13 | 10 | 9 | 10 | 10 | 11 | 10 | 10 | 9 | 11 | |
| II-91-003 | Carpet and underpad on 40 mm concrete on building paper | 84 | 50 | 36 | 35 | 32 | 24 | 22 | 20 | 20 | 17 | 13 | 12 | 6 | 6 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | |
| II-91-004 | Bare | 44 | 81 | 77 | 71 | 69 | 70 | 73 | 71 | 68 | 66 | 66 | 64 | 60 | 57 | 53 | 52 | 52 | 55 | 51 | 45 | 41 | 37 | |
| II-91-005 | 40 mm concrete on hard neoprene pads | 46 | 56 | 55 | 52 | 57 | 56 | 60 | 61 | 61 | 59 | 59 | 57 | 54 | 52 | 50 | 52 | 53 | 56 | 52 | 45 | 38 | 32 | |

| | | | |
|---|---|---|---|
| II-91-006 | 40 mm concrete on soft cork pads | 54 | 56 53 53 59 58 60 58 58 59 58 57 52 46 44 43 45 48 44 38 33 25 |
| II-91-007 | 40 mm concrete on hard cork pads | 48 | 56 54 53 58 57 60 59 59 59 59 58 53 50 49 49 51 54 50 45 39 31 |
| II-91-008 | 40 mm concrete on hard neoprene pads on joists | 48 | 54 54 53 58 57 61 59 58 59 59 58 53 51 48 49 51 54 51 45 39 32 |
| II-91-009 | 40 mm concrete on hard neoprene pads between joists | 50 | 55 55 53 58 60 61 58 59 59 59 58 53 49 47 49 50 52 48 42 34 28 |
| II-91-010 | 40 mm concrete on soft neoprene pads | 53 | 55 53 54 60 58 60 59 60 60 60 58 52 48 45 44 44 46 43 39 34 27 |
| II-91-011 | 40 mm concrete on very soft neoprene pads | 55 | 56 56 54 58 60 60 56 58 59 59 58 51 44 40 39 39 40 34 28 23 18 |
| II-91-012 | Float2 | 58 | 57 55 56 59 60 60 58 56 51 48 46 42 38 37 37 37 40 33 26 19 13 |
| II-91-013 | Float1 | 57 | 57 56 60 63 58 59 56 53 49 46 46 43 41 37 39 37 39 35 28 22 13 |
| II-91-014 | Float3 | 51 | 68 69 69 66 65 62 60 55 52 47 44 39 33 29 27 27 31 28 23 21 18 |
| II-91-015 | Carpet and underpad on Float3 | 75 | 51 47 45 41 32 25 22 18 15 13 9 7 8 7 8 9 12 9 8 9 10 |

**Truss1-w = PLY16_WT235_GFB90_GFB90_RC13_G16**

Resilient channels installed wrongly

| | | | |
|---|---|---|---|
| II-91-018 | Bare | 41 | 70 74 78 75 75 74 71 68 67 64 63 61 58 54 53 54 53 47 42 38 33 |
| II-91-024 | Carpet | 50 | 67 70 69 66 61 59 51 43 38 31 25 22 19 16 16 19 18 15 14 14 15 |
| II-91-027 | Carpet and Underpad | 65 | 52 54 55 50 41 38 32 30 29 23 13 13 10 9 9 9 8 8 8 8 9 |
| II-91-028 | Float1 | 55 | 58 65 63 65 61 58 57 54 51 47 43 41 39 35 36 40 38 34 26 20 17 |
| II-91-032 | Float2 | 55 | 57 63 62 65 63 60 59 56 53 47 42 40 37 34 38 41 38 29 25 21 17 |
| II-91-043 | Float3 | 47 | 68 72 72 69 65 64 61 57 51 45 38 34 29 25 24 23 22 22 23 24 25 |
| II-91-048 | Float3 | 46 | 71 71 74 68 62 61 59 54 48 43 38 33 27 23 19 19 18 17 15 15 16 |

**Truss1-13 = PLY16_WT235_GFB90_GFB90_RC13_G13**

Truss1 with 13 mm instead of 16 mm drywall

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-051 | bare | 45 | 78 | 79 | 74 | 70 | 71 | 71 | 70 | 67 | 65 | 63 | 60 | 56 | 53 | 49 | 46 | 44 | 44 | 45 | 41 | 35 | 30 |
| II-91-076 | Bare | 46 | 78 | 79 | 74 | 73 | 71 | 71 | 69 | 66 | 65 | 63 | 61 | 58 | 55 | 50 | 47 | 44 | 44 | 45 | 41 | 36 | 30 |

**Truss1 = PLY16_WT240_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-078 | Bare | 40 | 78 | 80 | 80 | 78 | 74 | 75 | 72 | 69 | 68 | 65 | 63 | 59 | 55 | 52 | 50 | 52 | 50 | 45 | 39 | 34 | 29 |
| II-91-079 | Carpet | 47 | 74 | 75 | 73 | 68 | 62 | 58 | 53 | 50 | 44 | 38 | 32 | 27 | 23 | 21 | 22 | 26 | 27 | 24 | 21 | 18 | 17 |
| II-91-080 | Carpet and underpad | 66 | 58 | 56 | 54 | 50 | 45 | 40 | 35 | 31 | 27 | 24 | 16 | 13 | 10 | 8 | 8 | 12 | 12 | 9 | 6 | 5 | 5 |
| II-91-112 | Float1 | 52 | 60 | 63 | 65 | 68 | 62 | 59 | 57 | 55 | 49 | 46 | 42 | 40 | 37 | 35 | 33 | 36 | 33 | 29 | 22 | 14 | 10 |
| II-91-113 | Float2 | 52 | 60 | 62 | 64 | 67 | 64 | 61 | 59 | 55 | 50 | 47 | 42 | 39 | 37 | 35 | 34 | 34 | 32 | 26 | 20 | 15 | 10 |
| II-91-114 | Float3 | 46 | 69 | 71 | 74 | 70 | 64 | 65 | 61 | 55 | 51 | 46 | 40 | 35 | 29 | 25 | 23 | 25 | 26 | 23 | 20 | 18 | 17 |

**Truss2 = PLY16_WT300_GFB75_GFB75_GFB75_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-119 | Bare | 48 | 77 | 74 | 70 | 66 | 67 | 67 | 67 | 67 | 66 | 62 | 61 | 59 | 54 | 50 | 47 | 46 | 47 | 44 | 38 | 32 | 27 |
| II-91-120 | Carpet | 57 | 74 | 71 | 63 | 59 | 54 | 50 | 46 | 41 | 35 | 25 | 21 | 17 | 11 | 10 | 9 | 10 | 10 | 9 | 9 | 12 | 10 |
| II-91-121 | Carpet and underpad | 72 | 60 | 55 | 47 | 41 | 33 | 29 | 26 | 25 | 20 | 13 | 11 | 8 | 6 | 8 | 5 | 5 | 5 | 5 | 5 | 10 | 8 |
| II-91-122 | Float1 | 59 | 58 | 57 | 61 | 59 | 55 | 52 | 51 | 49 | 47 | 41 | 39 | 37 | 35 | 31 | 29 | 31 | 30 | 25 | 17 | 11 | 7 |
| II-91-131 | Float2 | 60 | 58 | 55 | 57 | 58 | 58 | 54 | 53 | 53 | 51 | 45 | 43 | 40 | 36 | 34 | 35 | 36 | 37 | 32 | 22 | 14 | 9 |
| II-91-133 | Float3 | 50 | 70 | 69 | 69 | 65 | 63 | 60 | 56 | 53 | 50 | 43 | 39 | 34 | 28 | 21 | 16 | 14 | 13 | 10 | 10 | 12 | 11 |

**Conc1 = 150 mm concrete slab**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-138 | Bare | 25 | 49 | 50 | 55 | 62 | 63 | 64 | 67 | 75 | 67 | 76 | 73 | 75 | 75 | 77 | 76 | 77 | 76 | 75 | 73 | 70 | 64 |
| II-91-139 | Carpet | 68 | 44 | 45 | 48 | 52 | 50 | 48 | 45 | 51 | 37 | 38 | 30 | 23 | 15 | 13 | 9 | 7 | 5 | 3 | 3 | 7 | 4 |
| II-91-140 | Carpet and underpad | 86 | 30 | 26 | 31 | 34 | 26 | 25 | 23 | 28 | 16 | 19 | 12 | 4 | 0 | 0 | -0 | -0 | -0 | 0 | 1 | 2 | 3 |
| II-91-145 | CON40_GFR25_CON150 | 71 | 57 | 45 | 42 | 46 | 43 | 41 | 39 | 45 | 36 | 44 | 39 | 36 | 37 | 34 | 31 | 28 | 24 | 21 | 17 | 13 | 8 |
| II-91-146 | Float1 | 65 | 56 | 51 | 47 | 50 | 50 | 50 | 43 | 50 | 42 | 44 | 42 | 42 | 41 | 40 | 38 | 36 | 34 | 30 | 25 | 21 | 14 |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-147 | 40 mm concrete slab on 18 mm soft neoprene pads | 56 | 59 | 57 | 55 | 58 | 63 | 61 | 53 | 57 | 46 | 51 | 51 | 46 | 43 | 46 | 36 | 36 | 35 | 38 | 38 | 36 | 32 |
| II-91-148 | Float2 with no AF331 | 57 | 49 | 57 | 54 | 59 | 63 | 61 | 55 | 60 | 50 | 53 | 49 | 46 | 39 | 43 | 36 | 35 | 32 | 28 | 24 | 20 | 14 |
| II-91-149 | Float2 | 64 | 56 | 59 | 54 | 54 | 53 | 52 | 46 | 51 | 41 | 44 | 39 | 36 | 34 | 38 | 33 | 33 | 30 | 27 | 22 | 16 | 9 |
| II-91-150 | Float3 | 63 | 56 | 59 | 53 | 55 | 55 | 55 | 50 | 53 | 40 | 41 | 33 | 29 | 25 | 19 | 14 | 9 | 6 | 4 | 3 | 4 | 4 |
| II-91-153 | Float3 but with 80 mm deep furring | 66 | 54 | 52 | 51 | 52 | 52 | 53 | 47 | 50 | 40 | 40 | 32 | 26 | 22 | 19 | 13 | 7 | 3 | 3 | 2 | 3 | 3 |

**Truss3-e = PLY16_WT400_GFB90_GFB90_GFB90_RC13_G16**

**Not quite enough glass fibre**

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-155 | Bare | 46 | 75 | 71 | 70 | 69 | 66 | 67 | 73 | 71 | 68 | 65 | 64 | 60 | 55 | 52 | 48 | 45 | 45 | 47 | 42 | 37 | 31 | 26 |
| II-91-156 | Carpet | 59 | 72 | 67 | 66 | 61 | 57 | 57 | 54 | 48 | 41 | 36 | 32 | 24 | 18 | 15 | 14 | 12 | 14 | 16 | 13 | 12 | 15 | 13 |
| II-91-157 | Carpet and underpad | 69 | 64 | 57 | 51 | 51 | 44 | 37 | 33 | 29 | 26 | 24 | 22 | 12 | 8 | 6 | 10 | 5 | 6 | 7 | 6 | 7 | 13 | 10 |

**Truss3 = PLY16_WT400_GFB10_GFB90_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-158 | Bare | 49 | 73 | 69 | 69 | 68 | 64 | 69 | 70 | 67 | 65 | 62 | 60 | 57 | 52 | 49 | 45 | 43 | 43 | 45 | 40 | 35 | 29 | 25 |
| II-91-159 | Carpet | 57 | 72 | 66 | 67 | 62 | 58 | 57 | 52 | 46 | 40 | 33 | 28 | 22 | 16 | 13 | 12 | 11 | 13 | 14 | 12 | 10 | 14 | 12 |
| II-91-160 | Carpet and underpad | 70 | 63 | 55 | 49 | 50 | 43 | 35 | 31 | 26 | 25 | 23 | 21 | 10 | 6 | 5 | 12 | 5 | 5 | 6 | 6 | 7 | 13 | 11 |
| II-91-163 | Float1 | 55 | 63 | 60 | 59 | 65 | 61 | 55 | 51 | 52 | 52 | 48 | 45 | 39 | 37 | 33 | 32 | 30 | 32 | 33 | 27 | 19 | 14 | 11 |
| II-91-164 | Float2 | 59 | 63 | 60 | 56 | 59 | 61 | 59 | 52 | 54 | 55 | 50 | 48 | 43 | 39 | 34 | 33 | 32 | 34 | 34 | 27 | 21 | 15 | 11 |
| II-91-165 | Float3 | 51 | 70 | 69 | 69 | 68 | 62 | 58 | 57 | 56 | 53 | 47 | 42 | 37 | 32 | 28 | 24 | 22 | 21 | 21 | 19 | 17 | 16 | 15 |

**Joist3 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_RC13_G16**

With 19 mm wood fiberboard and Resilient channels

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-166 | Bare | 56 | 65 | 60 | 59 | 63 | 62 | 61 | 61 | 58 | 50 | 46 | 40 | 32 | 25 | 19 | 16 | 13 | 14 | 15 | 10 | 8 | 13 | 11 |
| II-91-167 | Carpet | 64 | 63 | 58 | 54 | 56 | 53 | 49 | 46 | 39 | 28 | 20 | 11 | 7 | 8 | 5 | 9 | 4 | 6 | 5 | 4 | 5 | 13 | 10 |
| II-91-168 | Carpet and underpad | 81 | 56 | 45 | 37 | 38 | 36 | 27 | 25 | 18 | 17 | 10 | 9 | 7 | 8 | 4 | 7 | 2 | 4 | 4 | 3 | 4 | 12 | 9 |
| II-91-169 | 40 mm concrete | 63 | 50 | 49 | 45 | 52 | 52 | 56 | 55 | 52 | 51 | 48 | 45 | 41 | 37 | 32 | 28 | 27 | 32 | 33 | 24 | 16 | 13 | 9 |

**Joist4 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Resilient channels removed from Joist3

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-170 | 40 mm concrete | 59 | 55 | 57 | 55 | 49 | 51 | 56 | 56 | 56 | 58 | 57 | 54 | 52 | 47 | 42 | 38 | 37 | 38 | 37 | 29 | 20 | 15 | 9 |
| II-91-171 | Bare | 54 | 73 | 69 | 64 | 62 | 61 | 65 | 64 | 61 | 60 | 59 | 53 | 47 | 38 | 33 | 25 | 22 | 22 | 20 | 13 | 10 | 13 | 11 |

**Joist5 = PLY16_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Wood fiberboard removed from Joist4

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II-91-172 | Bare | 52 | 75 | 72 | 67 | 64 | 62 | 64 | 65 | 65 | 61 | 60 | 58 | 52 | 44 | 40 | 30 | 27 | 27 | 25 | 20 | 18 | 17 | 15 |

*Table D3: Walker Data*

| TestID | Floor Topping or covering | TIC | 25 | 32 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Joist1 = PLY16_WJ240_GFB90_GFB90_GFB90_RC13_G16_G16** | | | | | | | | | | | | | | | | | | | | |
| WM90-028 | Bare | 71 | 48 | 55 | 55 | 64 | 61 | 57 | 50 | 44 | 44 | 41 | 44 | 41 | 41 | 39 | 39 | 38 | 37 | 31 |
| WM90-029 | Grey Carpet | 71 | 54 | 60 | 59 | 67 | 62 | 49 | 38 | 31 | 30 | 24 | 28 | 28 | 27 | 29 | 29 | 31 | 35 | 30 |
| WM90-033 | Brown Foam-backed carpet | 71 | 55 | 62 | 61 | 67 | 62 | 50 | 37 | 31 | 31 | 26 | 28 | 28 | 27 | 29 | 29 | 31 | 34 | 30 |
| WM90-036 | 18 mm Wonderboard screwed to plywood | 76 | 49 | 58 | 60 | 62 | 55 | 44 | 40 | 35 | 37 | 35 | 37 | 37 | 36 | 33 | 32 | 31 | 30 | 27 |
| WM90-037 | Grey carpet on 18 mm Wonderboard screwed to plywood | 75 | 53 | 62 | 63 | 63 | 54 | 39 | 31 | 28 | 27 | 25 | 26 | 25 | 25 | 25 | 24 | 26 | 28 | 28 |
| WM90-038 | Additional 16 mm plywood layer screwed to floor | 71 | 48 | 54 | 54 | 67 | 64 | 53 | 47 | 43 | 45 | 43 | 41 | 41 | 40 | 37 | 36 | 35 | 35 | 32 |
| **Joist2 = PLY16_WJ240_GFB90_RC13_G16** | | | | | | | | | | | | | | | | | | | | |
| In all following tests the carpet used was the Grey carpet and the underpad was the 9 mm thick blue foam underpad | | | | | | | | | | | | | | | | | | | | |
| WM91-001 | 40 mm concrete on building paper | 75 | 58 | 59 | 68 | 62 | 56 | 42 | 36 | 36 | 39 | 37 | 34 | 34 | 34 | 32 | 27 | 30 | 25 | 28 |
| WM91-002 | Carpet on 40 mm concrete on building paper | 71 | 63 | 62 | 71 | 66 | 59 | 41 | 32 | 28 | 29 | 24 | 23 | 23 | 24 | 25 | 21 | 22 | 21 | 19 |
| WM91-003 | Carpet and underpad on 40 mm concrete on building paper | 77 | 57 | 58 | 66 | 60 | 53 | 36 | 26 | 22 | 23 | 22 | 20 | 20 | 21 | 26 | 20 | 21 | 21 | 20 |
| WM91-004 | Bare | 64 | 58 | 59 | 63 | 73 | 70 | 60 | 54 | 52 | 56 | 52 | 49 | 50 | 48 | 46 | 46 | 43 | 40 | 40 |
| WM91-005 | 40 mm concrete on hard neoprene pads | 72 | 55 | 52 | 59 | 53 | 48 | 37 | 36 | 33 | 37 | 33 | 36 | 35 | 32 | 36 | 31 | 32 | 37 | 35 |
| WM91-006 | 40 mm concrete on soft cork pads | 79 | 56 | 52 | 61 | 55 | 49 | 38 | 33 | 34 | 36 | 34 | 34 | 33 | 32 | 32 | 27 | 25 | 26 | 25 |
| WM91-007 | 40 mm concrete on hard cork pads | 76 | 54 | 51 | 60 | 52 | 48 | 38 | 36 | 33 | 36 | 33 | 35 | 35 | 33 | 32 | 29 | 30 | 32 | 31 |
| WM91-008 | 40 mm concrete on hard neoprene pads on joists | 73 | 54 | 54 | 62 | 55 | 49 | 38 | 38 | 34 | 37 | 35 | 36 | 35 | 34 | 34 | 34 | 34 | 36 | 34 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-009 | 40 mm concrete on hard neoprene pads between joists | 81 | 53 | 48 | 55 | 50 | 45 | 36 | 37 | 36 | 37 | 35 | 31 | 33 | 31 | 29 | 27 | 23 | 23 | 27 |
| WM91-010 | 40 mm concrete on soft neoprene pads | 79 | 57 | 56 | 62 | 57 | 52 | 41 | 38 | 40 | 43 | 41 | 35 | 36 | 34 | 31 | 28 | 23 | 21 | 23 |
| WM91-011 | 40 mm concrete on very soft neoprene pads | 81 | 54 | 52 | 61 | 55 | 51 | 40 | 37 | 40 | 40 | 37 | 34 | 34 | 31 | 31 | 27 | 23 | 21 | 17 |
| WM91-012 | Float2 | 78 | 55 | 55 | 62 | 57 | 52 | 43 | 39 | 43 | 43 | 38 | 39 | 34 | 26 | 27 | 26 | 29 | 30 | 28 |
| WM91-013 | Float1 | 78 | 52 | 50 | 58 | 54 | 50 | 40 | 38 | 41 | 38 | 36 | 36 | 29 | 25 | 27 | 25 | 29 | 31 | 28 |
| WM91-014 | Float3 | 69 | 60 | 58 | 66 | 68 | 62 | 52 | 51 | 47 | 48 | 43 | 39 | 36 | 33 | 31 | 32 | 34 | 34 | 31 |
| WM91-015 | Carpet and underpad on Float3 | 74 | 56 | 52 | 59 | 59 | 53 | 41 | 38 | 34 | 34 | 29 | 27 | 28 | 29 | 31 | 33 | 34 | 35 | 33 |

**Truss1-w = PLY16_WT235_GFB90_GFB90_RC13_G16**

Resilient channels installed wrongly

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-018 | Bare | 61 | 61 | 59 | 62 | 69 | 64 | 64 | 60 | 55 | 60 | 55 | 53 | 51 | 46 | 45 | 42 | 38 | 36 | 30 |
| WM91-024 | Carpet | 73 | 63 | 59 | 62 | 65 | 58 | 54 | 46 | 35 | 35 | 30 | 27 | 25 | 24 | 21 | 20 | 18 | 24 | 22 |
| WM91-027 | Carpet and Underpad | 80 | 54 | 51 | 53 | 57 | 52 | 46 | 39 | 29 | 26 | 23 | 20 | 20 | 16 | 20 | 17 | 14 | 14 | 15 |
| WM91-028 | Float1 | 80 | 52 | 52 | 58 | 58 | 50 | 49 | 45 | 42 | 41 | 37 | 38 | 28 | 23 | 17 | 15 | 12 | 12 | 9 |
| WM91-032 | Float2 | 78 | 42 | 56 | 58 | 57 | 50 | 49 | 44 | 43 | 42 | 39 | 39 | 30 | 28 | 17 | 14 | 10 | 10 | 10 |
| WM91-043 | Float3 | 72 | 47 | 61 | 61 | 63 | 59 | 59 | 55 | 48 | 47 | 42 | 40 | 34 | 30 | 26 | 22 | 21 | 23 | 24 |
| WM91-048 | Float3 | 70 | 53 | 68 | 67 | 68 | 62 | 57 | 58 | 51 | 47 | 43 | 38 | 35 | 29 | 25 | 21 | 17 | 14 | 11 |

**Truss1-13 = PLY16_WT235_GFB90_GFB90_RC13_G13**

Truss1 with 13 mm instead of 16 mm drywall

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-051 | Bare | 68 | 53 | 68 | 67 | 70 | 67 | 62 | 59 | 52 | 54 | 51 | 49 | 46 | 43 | 40 | 38 | 35 | 31 | 25 |

**Truss1 = PLY16_WT240_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-077 | Bare | 61 | 50 | 61 | 62 | 69 | 64 | 63 | 62 | 60 | 61 | 56 | 53 | 51 | 48 | 44 | 42 | 38 | 36 | 30 |
| WM91-079 | Carpet | 69 | 50 | 63 | 66 | 69 | 63 | 53 | 49 | 45 | 42 | 34 | 30 | 31 | 27 | 25 | 22 | 25 | 19 | 20 |
| WM91-080 | Carpet and underpad | 75 | 44 | 57 | 59 | 62 | 57 | 48 | 44 | 38 | 36 | 32 | 26 | 30 | 25 | 23 | 21 | 23 | 18 | 18 |
| WM91-112 | Float1 | 73 | 49 | 58 | 59 | 62 | 53 | 45 | 43 | 50 | 48 | 41 | 38 | 33 | 26 | 21 | 18 | 17 | 15 | 14 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-113 | Float2 | 70 | 48 | 58 | 58 | 60 | 52 | 47 | 43 | 51 | 52 | 45 | 39 | 33 | 25 | 19 | 16 | 13 | 12 | 13 |
| WM91-114 | Float3 | 68 | 48 | 62 | 64 | 69 | 63 | 58 | 57 | 53 | 50 | 47 | 41 | 34 | 30 | 27 | 23 | 21 | 18 | 16 |

**Truss2 = PLY16_WT300_GFB75_GFB75_GFB75_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-119 | Bare | 68 | 50 | 61 | 62 | 68 | 64 | 54 | 53 | 48 | 51 | 48 | 50 | 47 | 44 | 40 | 38 | 35 | 31 | 25 |
| WM91-120 | Carpet | 69 | 53 | 63 | 63 | 69 | 64 | 49 | 41 | 32 | 31 | 25 | 28 | 24 | 20 | 15 | 14 | 15 | 14 | 14 |
| WM91-121 | Carpet and underpad | 75 | 48 | 59 | 59 | 62 | 57 | 44 | 35 | 31 | 30 | 25 | 28 | 25 | 21 | 15 | 14 | 14 | 11 | 11 |
| WM91-122 | Float1 | 77 | 52 | 61 | 64 | 61 | 52 | 41 | 39 | 42 | 38 | 36 | 33 | 29 | 23 | 20 | 15 | 16 | 12 | 12 |
| WM91-131 | Float2 | 79 | 49 | 59 | 61 | 58 | 51 | 39 | 37 | 44 | 41 | 37 | 35 | 31 | 26 | 20 | 15 | 18 | 11 | 12 |
| WM91-133 | Float3 | 69 | 47 | 59 | 60 | 69 | 63 | 53 | 49 | 45 | 44 | 40 | 37 | 32 | 28 | 23 | 19 | 18 | 13 | 12 |

**Conc1 = 150 mm concrete slab**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-138 | Bare | 65 | 39 | 37 | 43 | 50 | 43 | 35 | 35 | 39 | 45 | 45 | 43 | 48 | 44 | 47 | 39 | 39 | 39 | 35 |
| WM91-139 | Carpet | 87 | 42 | 41 | 45 | 51 | 42 | 31 | 25 | 24 | 22 | 20 | 15 | 20 | 12 | 15 | 11 | 10 | 9 | 8 |
| WM91-140 | Carpet and underpad | 94 | 36 | 34 | 39 | 43 | 34 | 24 | 18 | 19 | 20 | 20 | 16 | 20 | 14 | 15 | 10 | 9 | 7 | 7 |
| WM91-145 | CON40_GFR25_CON150 | 76 | 34 | 42 | 49 | 62 | 51 | 32 | 25 | 28 | 26 | 24 | 17 | 20 | 13 | 16 | 10 | 8 | 6 | 6 |
| WM91-146 | Float1 | 79 | 33 | 41 | 47 | 58 | 50 | 39 | 31 | 33 | 33 | 32 | 25 | 28 | 20 | 21 | 13 | 12 | 10 | 7 |
| WM91-147 | 40 mm concrete slab on 18 mm soft neoprene pads | 72 | 35 | 43 | 49 | 57 | 52 | 45 | 33 | 42 | 50 | 44 | 32 | 40 | 29 | 27 | 21 | 22 | 16 | 15 |
| WM91-148 | Float2 with no AF331 | 71 | 38 | 37 | 44 | 53 | 49 | 46 | 33 | 41 | 51 | 41 | 32 | 34 | 20 | 23 | 14 | 10 | 6 | 6 |
| WM91-149 | Float2 | 81 | 37 | 37 | 47 | 55 | 48 | 45 | 38 | 37 | 40 | 36 | 26 | 28 | 22 | 19 | 12 | 13 | 8 | 9 |
| WM91-150 | Float3 | 79 | 30 | 33 | 41 | 51 | 45 | 45 | 38 | 40 | 43 | 36 | 29 | 33 | 22 | 26 | 19 | 15 | 11 | 7 |
| WM91-153 | Float3 but with 80 mm deep furring | 80 | 33 | 38 | 45 | 58 | 50 | 39 | 33 | 36 | 39 | 33 | 28 | 36 | 23 | 27 | 18 | 15 | 9 | 8 |

**Truss3-s = PLY16_WT400_GFB90_GFB90_GFB90_RC13_G16**

**Not quite enough glass fibre**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-155 | Bare | 64 | 57 | 62 | 63 | 73 | 68 | 56 | 51 | 47 | 54 | 55 | 53 | 50 | 45 | 43 | 38 | 36 | 35 | 30 |
| WM91-156 | Carpet | 66 | 59 | 63 | 65 | 71 | 63 | 48 | 41 | 33 | 32 | 36 | 35 | 37 | 30 | 31 | 27 | 24 | 26 | 28 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-157 Carpet and underpad | 74 | 54 | 56 | 57 | 64 | 57 | 42 | 36 | 31 | 31 | 34 | 36 | 40 | 30 | 32 | 30 | 28 | 27 | 28 |

**Truss3 = PLY16_WT400_GFB10_GFB90_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-158 Bare | 66 | 59 | 61 | 63 | 72 | 66 | 56 | 50 | 46 | 53 | 51 | 48 | 45 | 42 | 40 | 35 | 33 | 31 | 26 |
| WM91-159 Carpet | 68 | 60 | 61 | 62 | 69 | 63 | 50 | 40 | 30 | 30 | 31 | 29 | 31 | 29 | 27 | 23 | 22 | 25 | 24 |
| WM91-160 Carpet and underpad | 76 | 55 | 55 | 56 | 62 | 56 | 43 | 35 | 26 | 28 | 30 | 27 | 29 | 29 | 27 | 22 | 21 | 24 | 24 |
| WM91-163 Float1 | 79 | 50 | 58 | 61 | 57 | 50 | 43 | 43 | 42 | 40 | 37 | 35 | 33 | 35 | 25 | 15 | 13 | 10 | 11 |
| WM91-164 Float2 | 76 | 51 | 59 | 62 | 59 | 51 | 43 | 41 | 45 | 45 | 39 | 33 | 33 | 28 | 21 | 15 | 12 | 9 | 9 |
| WM91-165 Float3 | 70 | 53 | 60 | 62 | 68 | 61 | 55 | 54 | 48 | 47 | 41 | 37 | 33 | 31 | 25 | 19 | 17 | 16 | 14 |

**Joist3 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_RC13_G16**

With 19 mm wood fiberboard and Resilient channels

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-166 Bare | 74 | 53 | 57 | 62 | 59 | 52 | 40 | 38 | 41 | 45 | 45 | 42 | 36 | 29 | 22 | 21 | 17 | 14 | 12 |
| WM91-167 Carpet | 77 | 58 | 62 | 65 | 60 | 53 | 35 | 28 | 25 | 28 | 30 | 22 | 24 | 21 | 18 | 19 | 16 | 13 | 11 |
| WM91-168 Carpet and underpad | 86 | 52 | 54 | 57 | 51 | 44 | 29 | 25 | 24 | 27 | 30 | 17 | 23 | 15 | 15 | 14 | 14 | 10 | 9 |
| WM91-169 40 mm concrete | 80 | 51 | 51 | 52 | 46 | 41 | 32 | 30 | 36 | 42 | 38 | 32 | 30 | 25 | 19 | 15 | 14 | 10 | 10 |

**Joist4 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Resilient channels removed from Joist3

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-170 40 mm concrete | 80 | 48 | 58 | 62 | 53 | 46 | 38 | 32 | 34 | 41 | 39 | 37 | 35 | 29 | 28 | 24 | 18 | 13 | 10 |
| WM91-171 Bare | 71 | 45 | 58 | 62 | 66 | 59 | 49 | 44 | 43 | 48 | 46 | 45 | 41 | 40 | 38 | 31 | 21 | 17 | 11 |

**Joist5 = PLY16_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Wood fiberboard removed from Joist4

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM91-172 Bare | 69 | 45 | 56 | 62 | 68 | 63 | 51 | 46 | 47 | 52 | 48 | 49 | 46 | 44 | 42 | 36 | 26 | 21 | 16 |

## *Table D4: Tire Machine Data*

| TestID | Floor topping or covering | TIC | 25 | 32 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Joist1 = PLY16_WJ240_GFB90_GFB90_GFB90_RC13_G16_G16** | | | | | | | | | | | | | | | | | | | | |
| TY90-028 | Bare | 41 | 83 | 91 | 91 | 97 | 91 | 80 | 66 | 60 | 57 | 57 | 59 | 58 | 53 | 51 | 50 | 50 | 50 | 46 |
| TY90-029 | Grey carpet | 39 | 83 | 90 | 92 | 99 | 93 | 79 | 64 | 57 | 55 | 53 | 56 | 57 | 51 | 46 | 45 | 45 | 43 | 40 |
| TY90-031 | 9 mm foam underpad and grey carpet | 38 | 82 | 90 | 92 | 100 | 95 | 75 | 62 | 55 | 54 | 49 | 52 | 54 | 50 | 47 | 46 | 45 | 43 | 40 |
| TY90-032 | 6 mm felt and grey carpet | 37 | 83 | 91 | 92 | 100 | 95 | 78 | 65 | 56 | 54 | 52 | 54 | 56 | 51 | 48 | 47 | 46 | 44 | 41 |
| TY90-033 | Brown foam-backed carpet | 38 | 83 | 90 | 91 | 99 | 94 | 80 | 65 | 58 | 54 | 53 | 55 | 56 | 51 | 46 | 46 | 45 | 44 | 41 |
| TY90-034 | 16 mm plywood raft on 6 mm felt | 37 | 83 | 91 | 94 | 101 | 93 | 75 | 65 | 56 | 54 | 52 | 52 | 55 | 51 | 48 | 48 | 49 | 47 | 45 |
| TY90-035 | 16 mm plywood raft on 3 mm neoprene | 37 | 83 | 91 | 93 | 100 | 93 | 75 | 64 | 56 | 53 | 53 | 52 | 55 | 53 | 51 | 49 | 46 | 47 | 45 |
| TY90-036 | 18 mm Wonderboard screwed to plywood | 42 | 83 | 93 | 95 | 95 | 88 | 75 | 66 | 60 | 58 | 53 | 53 | 55 | 51 | 49 | 47 | 46 | 44 | 43 |
| TY90-037 | Grey carpet on 18 mm Wonderboard screwed to plywood | 42 | 84 | 95 | 97 | 96 | 89 | 75 | 66 | 61 | 60 | 55 | 54 | 58 | 52 | 49 | 49 | 46 | 45 | 44 |
| TY90-038 | Additional 16 mm plywood layer screwed to floor | 35 | 82 | 90 | 93 | 102 | 97 | 79 | 67 | 61 | 59 | 57 | 57 | 57 | 54 | 53 | 53 | 52 | 53 | 55 |
| TY90-039 | 16 mm plywood raft glued to 11 mm fibreboard | 37 | 83 | 90 | 94 | 101 | 93 | 74 | 68 | 57 | 59 | 53 | 52 | 54 | 51 | 47 | 48 | 46 | 44 | 43 |
| **Joist2 = PLY16_WJ240_GFB90_RC13_G16** | | | | | | | | | | | | | | | | | | | | |
| In all following tests the carpet used was the Grey carpet and the underpad was the 9 mm thick blue foam underpad | | | | | | | | | | | | | | | | | | | | |
| TY91-001 | 40 mm concrete on building paper | 41 | 89 | 92 | 100 | 96 | 89 | 71 | 65 | 60 | 63 | 62 | 54 | 52 | 51 | 55 | 45 | 43 | 40 | 38 |
| TY91-002 | Carpet on 40 mm concrete on building paper | 42 | 88 | 92 | 100 | 96 | 87 | 69 | 65 | 58 | 65 | 63 | 56 | 54 | 52 | 55 | 46 | 42 | 40 | 37 |
| TY91-003 | Carpet and underpad on 40 mm concrete on building paper | 42 | 87 | 90 | 99 | 95 | 87 | 69 | 65 | 59 | 62 | 61 | 61 | 55 | 55 | 54 | 51 | 44 | 40 | 38 |
| TY91-004 | Bare | 28 | 93 | 93 | 100 | 109 | 103 | 87 | 81 | 80 | 82 | 75 | 71 | 69 | 67 | 64 | 63 | 62 | 57 | 54 |
| TY91-005 | 40 mm concrete on hard neoprene pads | 49 | 85 | 85 | 92 | 89 | 82 | 64 | 63 | 62 | 64 | 58 | 60 | 53 | 50 | 48 | 45 | 43 | 44 | 42 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-006 | 40 mm concrete on soft cork pads | 48 | 85 | 83 | 92 | 89 | 81 | 68 | 62 | 61 | 64 | 59 | 58 | 53 | 50 | 49 | 45 | 42 | 41 | 40 |
| TY91-007 | 40 mm concrete on hard cork pads | 47 | 85 | 85 | 93 | 91 | 82 | 64 | 62 | 61 | 61 | 59 | 59 | 52 | 49 | 49 | 46 | 42 | 41 | 39 |
| TY91-008 | 40 mm concrete on hard neoprene pads on joists | 48 | 84 | 87 | 94 | 90 | 82 | 64 | 65 | 64 | 63 | 58 | 56 | 50 | 51 | 49 | 45 | 42 | 40 | 38 |
| TY91-009 | 40 mm concrete on hard neoprene pads between joists | 48 | 86 | 83 | 92 | 89 | 84 | 67 | 65 | 62 | 64 | 64 | 56 | 55 | 51 | 51 | 46 | 43 | 42 | 40 |
| TY91-010 | 40 mm concrete on soft neoprene pads | 48 | 86 | 85 | 92 | 89 | 81 | 65 | 63 | 61 | 68 | 63 | 56 | 54 | 50 | 49 | 45 | 43 | 42 | 40 |
| TY91-011 | 40 mm concrete on very soft neoprene pads | 47 | 86 | 87 | 95 | 91 | 83 | 70 | 65 | 61 | 65 | 59 | 58 | 53 | 52 | 51 | 47 | 46 | 44 | 42 |
| TY91-012 | Float2 | 45 | 85 | 89 | 95 | 93 | 85 | 70 | 67 | 64 | 65 | 61 | 60 | 55 | 54 | 53 | 50 | 48 | 46 | 45 |
| TY91-013 | Float1 | 45 | 84 | 86 | 94 | 93 | 85 | 68 | 65 | 63 | 63 | 60 | 58 | 52 | 52 | 48 | 45 | 44 | 44 | 38 |
| TY91-014 | Float3 | 36 | 92 | 92 | 100 | 101 | 92 | 84 | 80 | 73 | 74 | 70 | 66 | 61 | 61 | 61 | 58 | 55 | 51 | 48 |
| TY91-015 | Carpet and underpad on Float3 | 39 | 93 | 93 | 100 | 99 | 90 | 86 | 79 | 71 | 72 | 71 | 66 | 63 | 62 | 61 | 58 | 57 | 51 | 49 |

**Truss1-w = PLY16_WT235_GFB90_GFB90_RC13_G16**

Resilient channels installed wrongly

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-018 | Bare | 35 | 83 | 96 | 98 | 102 | 94 | 89 | 84 | 75 | 77 | 72 | 66 | 65 | 61 | 56 | 55 | 51 | 52 | 49 |
| TY91-024 | Carpet | 35 | 93 | 90 | 98 | 103 | 94 | 88 | 82 | 74 | 76 | 71 | 70 | 66 | 60 | 59 | 57 | 56 | 56 | 55 |
| TY91-025 | Carpet | 36 | 93 | 90 | 97 | 101 | 94 | 88 | 82 | 76 | 75 | 72 | 69 | 62 | 59 | 55 | 53 | 50 | 51 | 47 |
| TY91-027 | Carpet and underpad | 37 | 93 | 92 | 98 | 100 | 92 | 87 | 79 | 75 | 74 | 70 | 67 | 63 | 59 | 54 | 52 | 49 | 50 | 48 |
| TY91-028 | Float1 | 47 | 83 | 81 | 88 | 91 | 83 | 80 | 69 | 64 | 63 | 54 | 53 | 48 | 42 | 39 | 39 | 38 | 37 | 38 |
| TY91-032 | Float2 | 50 | 76 | 89 | 90 | 87 | 81 | 76 | 70 | 66 | 65 | 56 | 54 | 47 | 43 | 39 | 40 | 35 | 34 | 33 |
| TY91-043 | Float3 | 39 | 82 | 96 | 97 | 99 | 96 | 92 | 84 | 73 | 74 | 67 | 62 | 57 | 54 | 52 | 47 | 47 | 49 | 51 |
| TY91-048 | Float3 | 38 | 83 | 96 | 98 | 99 | 94 | 88 | 87 | 74 | 69 | 63 | 56 | 54 | 49 | 47 | 44 | 43 | 42 | 39 |

**Truss1-13 = PLY16_WT235_GFB90_GFB90_RC13_G13**

Truss1 with 13 mm instead of 16 mm drywall

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-051 | Bare | 35 | 86 | 99 | 98 | 103 | 96 | 88 | 81 | 73 | 71 | 68 | 67 | 62 | 58 | 54 | 52 | 50 | 46 | 45 |

**Truss1 = PLY16_WT240_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-077 | Bare | 36 | 86 | 97 | 98 | 102 | 94 | 89 | 82 | 78 | 78 | 72 | 68 | 65 | 59 | 56 | 55 | 50 | 48 | 47 |
| TY91-079 | Carpet | 36 | 83 | 97 | 98 | 102 | 96 | 88 | 81 | 81 | 83 | 74 | 71 | 65 | 59 | 55 | 51 | 49 | 45 | 42 |
| TY91-080 | Carpet and underpad | 35 | 83 | 97 | 99 | 103 | 97 | 89 | 80 | 80 | 82 | 73 | 67 | 62 | 57 | 51 | 47 | 44 | 42 | 40 |
| TY91-112 | Float1 | 46 | 78 | 87 | 92 | 92 | 83 | 76 | 70 | 69 | 67 | 61 | 57 | 51 | 45 | 41 | 38 | 39 | 35 | 35 |
| TY91-113 | Float2 | 44 | 80 | 89 | 94 | 93 | 81 | 77 | 70 | 69 | 70 | 61 | 57 | 54 | 47 | 42 | 40 | 39 | 36 | 35 |
| TY91-114 | Float3 | 36 | 81 | 93 | 97 | 101 | 94 | 87 | 85 | 79 | 79 | 70 | 68 | 63 | 53 | 48 | 46 | 43 | 39 | 38 |

**Truss2 = PLY16_WT300_GFB75_GFB75_GFB75_RC13_G16**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-119 | Bare | 34 | 83 | 92 | 95 | 103 | 97 | 82 | 72 | 69 | 67 | 63 | 63 | 61 | 55 | 51 | 50 | 49 | 45 | 46 |
| TY91-120 | Carpet | 34 | 84 | 94 | 96 | 104 | 97 | 79 | 70 | 65 | 66 | 62 | 61 | 57 | 53 | 48 | 49 | 45 | 43 | 44 |
| TY91-121 | Carpet and underpad | 33 | 83 | 94 | 97 | 104 | 98 | 76 | 68 | 65 | 63 | 58 | 56 | 50 | 50 | 46 | 43 | 44 | 43 | 44 |
| TY91-122 | Float1 | 45 | 83 | 90 | 93 | 92 | 83 | 69 | 61 | 61 | 58 | 52 | 51 | 48 | 46 | 43 | 35 | 37 | 37 | 36 |
| TY91-131 | Float2 | 45 | 82 | 92 | 95 | 92 | 83 | 70 | 60 | 59 | 60 | 52 | 50 | 47 | 43 | 41 | 37 | 36 | 36 | 36 |
| TY91-133 | Float3 | 36 | 82 | 94 | 97 | 101 | 93 | 84 | 78 | 67 | 66 | 60 | 56 | 52 | 46 | 44 | 40 | 38 | 38 | 37 |

**Conc1 = 150 mm concrete slab**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-138 | Bare | 55 | 70 | 72 | 77 | 82 | 72 | 61 | 60 | 61 | 60 | 57 | 52 | 58 | 48 | 54 | 49 | 50 | 45 | 44 |
| TY91-139 | Carpet | 55 | 68 | 71 | 77 | 82 | 73 | 60 | 58 | 63 | 58 | 56 | 51 | 57 | 46 | 50 | 45 | 43 | 35 | 31 |
| TY91-140 | Carpet and underpad | 54 | 67 | 70 | 77 | 84 | 74 | 56 | 54 | 60 | 58 | 53 | 48 | 57 | 45 | 45 | 41 | 35 | 27 | 21 |
| TY91-145 | CON40_GFR25_CON150 | 44 | 63 | 73 | 81 | 94 | 82 | 62 | 52 | 50 | 48 | 39 | 32 | 33 | 27 | 26 | 24 | 22 | 23 | 23 |
| TY91-146 | Float1 | 46 | 62 | 72 | 79 | 91 | 82 | 70 | 62 | 57 | 50 | 46 | 36 | 38 | 29 | 26 | 24 | 22 | 22 | 24 |
| TY91-147 | 40 mm concrete slab on 18 mm soft neoprene pads | 47 | 62 | 74 | 78 | 90 | 84 | 71 | 55 | 62 | 68 | 57 | 44 | 47 | 33 | 32 | 28 | 28 | 23 | 25 |
| TY91-148 | Float2 with no AF331 | 49 | 65 | 68 | 76 | 87 | 79 | 71 | 53 | 64 | 72 | 59 | 47 | 46 | 32 | 32 | 25 | 22 | 22 | 23 |
| TY91-149 | Float2 | 55 | 64 | 68 | 76 | 83 | 75 | 74 | 66 | 56 | 56 | 50 | 36 | 38 | 30 | 26 | 21 | 19 | 15 | 17 |
| TY91-150 | Float3 | 52 | 60 | 70 | 78 | 86 | 79 | 76 | 68 | 65 | 65 | 55 | 44 | 50 | 36 | 43 | 38 | 38 | 25 | 18 |
| TY91-153 | Float3 but with 80 mm deep furring | 44 | 60 | 70 | 80 | 93 | 86 | 74 | 66 | 67 | 69 | 57 | 48 | 57 | 47 | 57 | 50 | 49 | 35 | 26 |

**Truss3-e = PLY16_WT400_GFB90_GFB90_GFB90_RC13_G16**

**not quite enough glass fibre**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-155 | Bare | 31 | 87 | 96 | 100 | 106 | 96 | 84 | 77 | 70 | 74 | 70 | 66 | 62 | 58 | 54 | 52 | 49 | 47 | 46 |
| TY91-156 | Carpet | 34 | 87 | 96 | 100 | 103 | 92 | 81 | 76 | 68 | 73 | 67 | 64 | 59 | 56 | 53 | 49 | 48 | 46 | 45 |
| TY91-157 | Carpet and underpad | 36 | 87 | 98 | 100 | 102 | 90 | 80 | 74 | 68 | 72 | 68 | 63 | 61 | 58 | 53 | 49 | 49 | 47 | 44 |

**Truss3 = PLY16_WT400_GFB10_GFB90_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-158 | Bare | 34 | 87 | 94 | 99 | 104 | 95 | 84 | 74 | 68 | 71 | 66 | 65 | 61 | 58 | 53 | 50 | 48 | 46 | 45 |
| TY91-159 | Carpet | 35 | 87 | 95 | 99 | 102 | 93 | 81 | 71 | 67 | 69 | 64 | 63 | 57 | 55 | 52 | 47 | 46 | 45 | 43 |
| TY91-160 | Carpet and underpad | 36 | 87 | 95 | 99 | 101 | 91 | 79 | 69 | 66 | 67 | 62 | 59 | 56 | 54 | 50 | 46 | 44 | 44 | 43 |
| TY91-163 | Float1 | 45 | 80 | 89 | 93 | 93 | 85 | 71 | 67 | 61 | 56 | 49 | 45 | 42 | 38 | 38 | 35 | 35 | 35 | 34 |
| TY91-164 | Float2 | 45 | 81 | 90 | 92 | 93 | 86 | 72 | 64 | 61 | 60 | 52 | 50 | 44 | 41 | 41 | 37 | 37 | 38 | 36 |
| TY91-165 | Float3 | 37 | 83 | 92 | 98 | 100 | 93 | 84 | 80 | 68 | 64 | 60 | 55 | 50 | 46 | 46 | 44 | 40 | 41 | 39 |

**Joist3 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_RC13_G16**

With 19 mm wood fibre board and Resilient channels

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91_166 | Bare | 43 | 85 | 91 | 97 | 94 | 88 | 72 | 67 | 61 | 64 | 61 | 55 | 51 | 48 | 47 | 46 | 46 | 47 | 48 |
| TY91_167 | Carpet | 44 | 84 | 93 | 98 | 93 | 86 | 70 | 67 | 62 | 64 | 59 | 54 | 51 | 51 | 46 | 45 | 46 | 45 | 45 |
| TY91_168 | Carpet and underpad | 45 | 84 | 94 | 99 | 92 | 84 | 67 | 67 | 62 | 63 | 58 | 53 | 52 | 51 | 46 | 45 | 45 | 44 | 44 |
| TY91_169 | 40 mm concrete | 57 | 83 | 83 | 84 | 81 | 77 | 60 | 58 | 56 | 60 | 53 | 48 | 45 | 42 | 37 | 36 | 38 | 39 | 39 |

**Joist4 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Resilient channels removed from Joist3

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91_170 | 40 mm concrete | 54 | 79 | 90 | 92 | 83 | 76 | 67 | 62 | 53 | 56 | 53 | 51 | 46 | 43 | 37 | 34 | 31 | 27 | 29 |
| TY91_171 | Bare | 39 | 80 | 92 | 97 | 99 | 90 | 74 | 70 | 61 | 66 | 62 | 57 | 50 | 50 | 47 | 46 | 46 | 47 | 48 |

**Joist5 = PLY16_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

19 mm Wood fiberboard removed from Joist4

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TY91-172 | Bare | 39 | 79 | 91 | 94 | 99 | 91 | 77 | 68 | 61 | 64 | 60 | 58 | 55 | 53 | 49 | 47 | 47 | 48 | 49 |

## *Table D5: NRC Special Impact Device Data*

| TestID | Floor Topping or covering | TIC | 25 | 32 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Joist1=PLY16_WJ240_GFB90_GFB90_GFB90_RC13_G16_G16** | | | | | | | | | | | | | | | | | | | | |
| SI-90-028 | Bare | 65 | 59 | 56 | 56 | 60 | 53 | 45 | 38 | 42 | 37 | 47 | 52 | 49 | 46 | 46 | 45 | 42 | 41 | 34 |
| SI-90-029 | Grey carpet | 85 | 53 | 53 | 47 | 52 | 47 | 39 | 31 | 35 | 23 | 18 | 19 | 14 | 13 | 13 | 9 | 10 | 14 | 11 |
| SI-90-031 | 9 mm foam underpad and grey carpet | 95 | 36 | 43 | 38 | 43 | 38 | 32 | 28 | 24 | 17 | 15 | 15 | 14 | 13 | 13 | 9 | 9 | 8 | 13 |
| SI-90-032 | 6 mm felt and grey carpet | 87 | 50 | 51 | 44 | 49 | 45 | 34 | 31 | 32 | 24 | 22 | 21 | 20 | 21 | 24 | 18 | 16 | 21 | 17 |
| SI-90-033 | Brown foam-backed carpet | 83 | 49 | 49 | 48 | 54 | 48 | 38 | 25 | 27 | 18 | 18 | 18 | 16 | 14 | 15 | 10 | 9 | 10 | 9 |
| SI-90-034 | 16 mm plywood raft on 6 mm felt | 70 | 58 | 58 | 55 | 64 | 59 | 38 | 33 | 37 | 35 | 41 | 44 | 45 | 42 | 38 | 37 | 34 | 32 | 23 |
| SI-90-035 | 16 mm plywood raft on 3 mm neoprene | 65 | 59 | 60 | 57 | 68 | 64 | 43 | 36 | 40 | 39 | 44 | 45 | 49 | 46 | 43 | 45 | 41 | 35 | 29 |
| SI-90-036 | 18 mm Wonderboard screwed to plywood | 69 | 60 | 63 | 62 | 68 | 60 | 44 | 37 | 40 | 39 | 40 | 43 | 44 | 44 | 40 | 38 | 36 | 33 | 32 |
| SI-90-037 | Grey carpet on 18 mm Wonderboard screwed to plywood | 83 | 52 | 54 | 53 | 55 | 46 | 30 | 25 | 29 | 24 | 17 | 15 | 14 | 13 | 13 | 9 | 9 | 9 | 10 |
| SI-90-038 | Additional 16 mm plywood layer screwed to floor | 68 | 56 | 59 | 54 | 61 | 57 | 46 | 34 | 35 | 37 | 42 | 43 | 42 | 44 | 42 | 43 | 38 | 36 | 30 |
| SI-90-039 | 16 mm plywood raft glued to 11 mm fibreboard | 71 | 59 | 60 | 53 | 64 | 60 | 43 | 32 | 33 | 31 | 33 | 31 | 37 | 40 | 40 | 38 | 32 | 29 | 24 |
| **Joist2 = PLY16_WJ240_GFB90_RC13_G16** | | | | | | | | | | | | | | | | | | | | |
| In all following tests the carpet used was the Grey carpet and the underpad was the 9 mm thick blue foam underpad | | | | | | | | | | | | | | | | | | | | |
| SI-91-001 | 40 mm concrete on building paper | 77 | 64 | 60 | 68 | 61 | 50 | 35 | 25 | 29 | 34 | 29 | 28 | 34 | 30 | 32 | 26 | 20 | 17 | 11 |
| SI-91-002 | Carpet on 40 mm concrete on building paper | 77 | 59 | 55 | 68 | 62 | 53 | 30 | 26 | 32 | 29 | 23 | 24 | 22 | 26 | 21 | 19 | 19 | 16 | 18 |
| SI-91-003 | Carpet and underpad on 40 mm concrete on building paper | 90 | 43 | 41 | 46 | 40 | 36 | 24 | 22 | 25 | 23 | 26 | 18 | 23 | 21 | 18 | 20 | 10 | 8 | 8 |
| SI-91-004 | Bare | 60 | 66 | 56 | 60 | 73 | 72 | 52 | 52 | 42 | 47 | 47 | 48 | 50 | 46 | 50 | 51 | 46 | 40 | 36 |
| SI-91-005 | 40 mm concrete on hard neoprene pads | 78 | 63 | 55 | 56 | 53 | 46 | 32 | 26 | 27 | 33 | 30 | 36 | 36 | 31 | 34 | 33 | 24 | 21 | 18 |
| SI-91-006 | 40 mm concrete on soft cork pads | 78 | 63 | 51 | 55 | 55 | 47 | 33 | 25 | 26 | 33 | 31 | 32 | 30 | 31 | 35 | 33 | 25 | 18 | 19 |
| SI-91-007 | 40 mm concrete on hard cork pads | 76 | 62 | 54 | 55 | 53 | 47 | 32 | 26 | 29 | 32 | 33 | 34 | 34 | 32 | 32 | 35 | 26 | 21 | 16 |
| SI-91-008 | 40 mm concrete on hard neoprene pads on joists | 77 | 62 | 55 | 57 | 52 | 46 | 33 | 28 | 27 | 31 | 32 | 32 | 29 | 31 | 35 | 33 | 25 | 17 | 16 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-009 | 40 mm concrete on hard neoprene pads between joists | 77 | 63 | 52 | 53 | 54 | 46 | 36 | 27 | 30 | 36 | 38 | 29 | 33 | 30 | 34 | 31 | 22 | 15 | 10 |
| SI-91-010 | 40 mm concrete on soft neoprene pads | 75 | 62 | 55 | 54 | 52 | 45 | 32 | 31 | 31 | 36 | 36 | 30 | 33 | 31 | 36 | 33 | 25 | 19 | 17 |
| SI-91-011 | 40 mm concrete on very soft neoprene pads | 77 | 63 | 52 | 58 | 56 | 47 | 35 | 27 | 30 | 37 | 34 | 31 | 32 | 30 | 34 | 31 | 22 | 11 | 8 |
| SI-91-012 | Float2 | 84 | 60 | 57 | 57 | 52 | 46 | 36 | 35 | 33 | 38 | 31 | 33 | 30 | 22 | 23 | 20 | 14 | 11 | 9 |
| SI-91-013 | Float1 | 84 | 60 | 54 | 57 | 53 | 46 | 36 | 33 | 34 | 37 | 32 | 30 | 26 | 20 | 21 | 19 | 14 | 11 | 10 |
| SI-91-014 | Float3 | 74 | 58 | 56 | 57 | 59 | 53 | 41 | 37 | 38 | 43 | 37 | 35 | 36 | 39 | 37 | 34 | 30 | 21 | 14 |
| SI-91-015 | Carpet and underpad on Float3 | 96 | 41 | 36 | 42 | 42 | 36 | 25 | 22 | 24 | 18 | 17 | 16 | 12 | 12 | 15 | 11 | 9 | 7 | 8 |

**Truss1-w = PLY16_WT235_GFB90_GFB90_RC13_G16**

Resilient channels installed wrongly

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-018 | Bare | 61 | 67 | 55 | 56 | 59 | 52 | 47 | 44 | 43 | 49 | 41 | 47 | 52 | 52 | 50 | 46 | 39 | 35 | 31 |
| SI-91-024 | Carpet | 82 | 58 | 55 | 59 | 56 | 52 | 42 | 38 | 37 | 39 | 28 | 21 | 19 | 16 | 17 | 19 | 14 | 12 | 13 |
| SI-91-027 | Carpet and underpad | 92 | 39 | 40 | 38 | 39 | 36 | 29 | 28 | 21 | 17 | 16 | 15 | 19 | 15 | 20 | 17 | 13 | 11 | 12 |
| SI-91-028 | Float1 | 82 | 57 | 51 | 51 | 55 | 45 | 39 | 32 | 31 | 33 | 28 | 30 | 24 | 21 | 20 | 14 | 10 | 10 | 15 |
| SI-91-032 | Float2 | 85 | 48 | 58 | 56 | 49 | 41 | 38 | 30 | 30 | 35 | 30 | 33 | 28 | 27 | 20 | 14 | 9 | 9 | 9 |
| SI-91-043 | Float3 | 73 | 47 | 61 | 58 | 56 | 49 | 50 | 43 | 41 | 45 | 36 | 38 | 37 | 37 | 38 | 30 | 22 | 19 | 17 |
| SI-91-048 | Float3 | 79 | 48 | 63 | 59 | 58 | 52 | 44 | 42 | 40 | 39 | 36 | 34 | 32 | 30 | 33 | 27 | 22 | 15 | 11 |

**Truss1-13 = PLY16_WT235_GFB90_GFB90_RC13_G13**

**Truss1 with 13 mm instead of 16 mm Drywall**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-051 | Bare | 62 | 60 | 64 | 61 | 62 | 57 | 55 | 43 | 44 | 49 | 47 | 47 | 45 | 43 | 47 | 48 | 41 | 33 | 31 |

**Truss1 = PLY16_WT240_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-077 | Bare | 63 | 58 | 61 | 60 | 65 | 57 | 49 | 46 | 50 | 51 | 50 | 50 | 49 | 49 | 49 | 47 | 43 | 37 | 34 |
| SI-91-079 | Carpet | 71 | 52 | 57 | 60 | 67 | 61 | 47 | 43 | 41 | 40 | 38 | 32 | 28 | 22 | 17 | 14 | 13 | 12 | 12 |
| SI-91-080 | Carpet and underpad | 84 | 38 | 48 | 53 | 53 | 46 | 35 | 30 | 27 | 27 | 30 | 18 | 27 | 21 | 17 | 14 | 11 | 10 | 11 |
| SI-91-112 | Float1 | 76 | 58 | 61 | 58 | 62 | 54 | 46 | 38 | 45 | 45 | 41 | 35 | 32 | 27 | 25 | 22 | 19 | 17 | 15 |
| SI-91-113 | Float2 | 74 | 55 | 61 | 58 | 60 | 48 | 44 | 37 | 43 | 48 | 41 | 38 | 34 | 32 | 25 | 21 | 16 | 13 | 13 |
| SI-91-114 | Float3 | 77 | 45 | 57 | 57 | 58 | 50 | 47 | 43 | 44 | 44 | 40 | 38 | 32 | 35 | 34 | 29 | 24 | 19 | 14 |

**Truss2 = PLY16_WT300_GFB75_GFB75_GFB75_RC13_G16**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-119 | Bare | 67 | 60 | 63 | 61 | 66 | 61 | 53 | 40 | 41 | 48 | 44 | 48 | 45 | 44 | 43 | 44 | 40 | 35 | 29 |
| SI-91-120 | Carpet | 76 | 56 | 61 | 61 | 61 | 58 | 46 | 33 | 33 | 36 | 27 | 25 | 20 | 13 | 9 | 10 | 10 | 9 | 10 |
| SI-91-121 | Carpet and underpad | 88 | 38 | 44 | 44 | 49 | 46 | 34 | 24 | 24 | 21 | 20 | 16 | 19 | 13 | 10 | 10 | 10 | 8 | 9 |
| SI-91-122 | Float1 | 76 | 55 | 56 | 61 | 61 | 48 | 29 | 27 | 31 | 30 | 27 | 27 | 26 | 22 | 20 | 17 | 15 | 11 | 11 |
| SI-91-131 | Float2 | 84 | 54 | 57 | 58 | 53 | 47 | 29 | 26 | 29 | 33 | 28 | 28 | 26 | 24 | 22 | 18 | 18 | 12 | 12 |
| SI-91-133 | Float3 | 80 | 47 | 49 | 56 | 58 | 52 | 38 | 37 | 33 | 37 | 33 | 33 | 32 | 32 | 30 | 27 | 22 | 17 | 12 |

**Conc1 = 150 mm concrete slab**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-138 | Bare | 56 | 42 | 45 | 47 | 48 | 37 | 27 | 26 | 36 | 41 | 38 | 39 | 48 | 43 | 55 | 50 | 50 | 45 | 42 |
| SI-91-139 | Carpet | 84 | 40 | 36 | 47 | 53 | 42 | 26 | 21 | 30 | 33 | 25 | 19 | 21 | 14 | 9 | 5 | 8 | 6 | 7 |
| SI-91-140 | Carpet and underpad | 97 | 27 | 24 | 27 | 33 | 27 | 20 | 14 | 18 | 18 | 19 | 13 | 19 | 11 | 12 | 9 | 8 | 7 | 7 |
| SI-91-145 | CON40_GFR25_CON150 | 82 | 41 | 46 | 44 | 55 | 47 | 27 | 19 | 24 | 26 | 19 | 14 | 21 | 14 | 23 | 17 | 10 | 7 | 6 |
| SI-91-146 | Float1 | 86 | 40 | 45 | 45 | 50 | 43 | 34 | 25 | 28 | 31 | 26 | 19 | 26 | 18 | 25 | 20 | 14 | 11 | 8 |
| SI-91-147 | 40 mm concrete slab on 18 mm soft neoprene pads | 75 | 42 | 41 | 47 | 49 | 45 | 37 | 23 | 39 | 47 | 40 | 30 | 38 | 28 | 30 | 27 | 30 | 16 | 18 |
| SI-91-148 | Float2 with no AF331 | 75 | 47 | 37 | 45 | 43 | 37 | 35 | 21 | 36 | 46 | 34 | 28 | 31 | 21 | 24 | 17 | 12 | 6 | 6 |
| SI-91-149 | Float2 | 82 | 41 | 41 | 42 | 44 | 38 | 39 | 29 | 33 | 39 | 32 | 24 | 32 | 24 | 24 | 19 | 16 | 8 | 10 |
| SI-91-150 | Float3 | 74 | 40 | 33 | 39 | 44 | 36 | 31 | 24 | 33 | 40 | 35 | 35 | 42 | 29 | 35 | 28 | 22 | 15 | 11 |
| SI-91-153 | Float3 but with 80 mm deep furring | 76 | 37 | 35 | 39 | 55 | 47 | 30 | 24 | 32 | 38 | 31 | 30 | 40 | 25 | 32 | 26 | 21 | 11 | 10 |

**Truss3-e = PLY16_WT400_GFB90_GFB90_GFB90_RC13_G16**

not quite enough glass fibre

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-155 | Bare | 65 | 63 | 61 | 55 | 71 | 65 | 51 | 44 | 36 | 43 | 51 | 53 | 49 | 46 | 47 | 44 | 42 | 38 | 34 |
| SI-91-156 | Carpet | 72 | 57 | 53 | 58 | 65 | 56 | 48 | 43 | 31 | 35 | 30 | 32 | 22 | 18 | 16 | 13 | 13 | 14 | 14 |
| SI-91-157 | Carpet and underpad | 87 | 42 | 41 | 40 | 51 | 44 | 31 | 25 | 18 | 21 | 24 | 17 | 18 | 13 | 14 | 9 | 8 | 7 | 8 |

**Truss3 = PLY16_WT400_GFB10_GFB90_GFB90_GFB90_RC13_G16**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-158 | Bare | 61 | 62 | 59 | 59 | 76 | 71 | 54 | 44 | 35 | 44 | 49 | 49 | 44 | 44 | 46 | 43 | 40 | 36 | 31 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-159 | Carpet | 65 | 58 | 56 | 61 | 73 | 67 | 51 | 42 | 31 | 36 | 32 | 28 | 23 | 19 | 16 | 13 | 14 | 13 | 14 |
| SI-91-160 | Carpet and underpad | 79 | 44 | 44 | 49 | 58 | 51 | 36 | 31 | 21 | 25 | 29 | 17 | 21 | 18 | 13 | 9 | 9 | 7 | 8 |
| SI-91-163 | Float1 | 71 | 55 | 60 | 65 | 66 | 55 | 39 | 36 | 37 | 34 | 30 | 31 | 28 | 26 | 22 | 16 | 12 | 9 | 9 |
| SI-91-164 | Float2 | 75 | 56 | 61 | 63 | 62 | 52 | 37 | 30 | 35 | 38 | 33 | 30 | 30 | 26 | 25 | 21 | 15 | 10 | 10 |
| SI-91-165 | Float3 | 66 | 54 | 56 | 59 | 72 | 64 | 49 | 40 | 37 | 41 | 39 | 37 | 35 | 33 | 30 | 26 | 24 | 19 | 15 |

**Joist3 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_RC13_G16**

**With 19 mm wood fiberboard and Resilient channels**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-166 | Bare | 74 | 64 | 56 | 58 | 50 | 44 | 37 | 27 | 33 | 41 | 46 | 42 | 36 | 32 | 24 | 21 | 17 | 13 | 11 |
| SI-91-167 | Carpet | 79 | 59 | 50 | 57 | 59 | 48 | 32 | 22 | 29 | 33 | 33 | 26 | 24 | 16 | 18 | 14 | 15 | 14 | 12 |
| SI-91-168 | Carpet and underpad | 89 | 42 | 41 | 48 | 43 | 37 | 24 | 18 | 20 | 26 | 30 | 15 | 23 | 14 | 14 | 11 | 14 | 11 | 9 |
| SI-91-169 | 40 mm concrete | 85 | 58 | 56 | 54 | 47 | 42 | 31 | 21 | 26 | 33 | 35 | 30 | 30 | 28 | 22 | 19 | 17 | 15 | 13 |

**Joist4 = PLY16_WFB19_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Resilient channels removed from Joist3

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-170 | 40 mm concrete | 79 | 54 | 59 | 60 | 54 | 48 | 35 | 22 | 25 | 34 | 33 | 33 | 34 | 35 | 31 | 30 | 22 | 14 | 12 |
| SI-91-171 | Bare | 73 | 58 | 55 | 56 | 57 | 52 | 37 | 30 | 36 | 43 | 41 | 44 | 43 | 40 | 37 | 35 | 25 | 21 | 14 |

**Joist5 = PLY16_WJ240_GFB200_AIR80_WJ140_GFB150_G16**

Wood fiberboard removed from Joist4

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI-91-172 | Bare | 68 | 56 | 53 | 56 | 61 | 55 | 41 | 31 | 37 | 43 | 43 | 50 | 47 | 43 | 43 | 39 | 31 | 24 | 17 |

## References


1 JIS 1418 Japanese National Standard describing impact testing of floors.

2 ASTM E492, Standard Method of Laboratory Measurement of Impact Sound Transmission through Floor-ceiling Assemblies using the Tapping Machine.

3 ASTM E989, Classification for Determination of Impact Insulation Class.

4 ASTM E90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.

5 ASTM E413 Classification for Rating Sound Insulation.

6 Seminar on Impact sound insulation test methods. SINTEF Report No. STF 44 A820222, J.T. Broch, The Norwegian Institute of Technology, 1982.

7 Rating of Impact Sound Insulation between dwellings", Kaj Bodlund, Statens Provningsanstalt, Technical Report 1985:01, also J. Sound and Vibration, 102(3), p381, 1985.

8 ISO 717 Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation.

9 Sound Performance of wood Floor/Ceiling Assemblies (Stage II), C.W. Bradley, Report 89-114.